Effect of improved technologies on income of smallholder rubber farmers in Indonesia

(技術進歩がインドネシアのゴム作農家の所得に及ぼす効果)

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Table of Contents

List of Table

List of Figures

Chapter 1

Introduction

1.1 Natural Rubber in the World Market

Indonesia is the second largest exporter of natural rubber in the world, and it plays an important role in the world's natural rubber market. In 2001 and 2010, Indonesia contributed 29% of the total global natural rubber export (International Rubber Study Group, 2012b). Indonesia and its neighboring countries Thailand and Malaysia account for more than 70% of total natural rubber exports worldwide (Table 1.1).

Among all of the rubber-producing countries, Indonesia contributed 22% of total world rubber production in 2001, increasing to 27% in 2010. Indonesia has the largest area of rubber plantations worldwide: 2.6 million ha in 2001 and 3.4 million ha in 2010, or 33% and 36% of the global rubber plantation area in 2001 and 2010 (Food and Agriculture Organization, 2011), respectively. Together, Indonesia, Thailand, and Malaysia account for 68% of the total rubber plantation area globally. However, among these main producing countries, Indonesia's rubber productivity is the lowest, at 993 kg/ha (Association of Natural Rubber Producing Countries, 2010) (Table 1.2). This low productivity prevents Indonesia from being the largest rubber producer in the world.

Generally, there are two types of rubber, natural and synthetic. The former is produced by the rubber tree and the latter is produced from petrochemical resources. Natural rubber has become more prominent in the international rubber market, increasing from 35% in 2001 to 55% in 2010 (Table 1.3). These goods are close substitutes for each other in many product applications, where price and availability are the main factors in selecting elastomers (Grilli et al., 1980, p. 51).

The demand for both synthetic and natural rubber has increased with the growth of the tire, gloves, shoes, and styrofoam industries. The countries with the strongest demands for natural rubber are China, the United States, Japan, and India, which together consumed 50% of the natural rubber in 2001 and 58% in 2010 (Table 1.4).

1.2 Natural Rubber in the Indonesian Economy

The rubber sector accounts for 5% of total exports from Indonesia, the second highest export share among plantation crops, and has increased from only 1% of total exports in 2000 (Table 1.5). Therefore, the rubber sector makes a substantial contribution to providing international currency reserves. The rubber sector includes two related sectors, the rubber crop sector and the rubber manufacturing sector. The latter converts raw rubber materials into other products such as technically specified rubber (TSR), ribbed smoked sheet (RSS), and other products.

As a single sector, the rubber crop sector contributed 1% of total wages and salaries in Indonesia in 1995 and in 2005. This contribution is the highest among all of the estate crops (code 7-16), and the fourth highest in the agricultural sector (Table 1.6). Therefore, the rubber crop sector provides employment for a substantial portion of the Indonesian population.

The income from rubber crops contributes 11.9% of total farmer household income, the highest proportion among estate crops, but lower than the proportion of income derived from wetland paddy crops and fisheries (including sea, field, and catch fisheries) (Table 1.7).

1.3 General Conditions of Natural Rubber Farms in Indonesia

There are three types of rubber plantations in Indonesia: smallholder rubber farms, government plantations, and private plantations. Smallholder rubber farms are small-scale farms managed by household farmers, whereas government plantations and private plantations are large-scale farms managed by the government and private companies, respectively. Among these categories, smallholder rubber farms account for 80% of the total rubber production and 85% of the production area, whereas government and private plantations account for 9% and 10% of total rubber production, respectively (Table 1.8).

Rubber farms are densely distributed in Sumatra Island, Kalimantan Island, and in some parts of Java. The smallholder farms are most densely distributed in Sumatra and Kalimantan Island (Figure 1.1 and Table 1.9). The government and private plantations are mainly located in Sumatra and Java and in some parts of Kalimantan Island.

Among the tree rubber producers in Indonesia, government and private plantations have higher productivity (1,509 and 1,553 kg/ha/year, respectively) than that of smallholder farms (1,036 kg/ha/year). Although productivity has increased over time, it is still low (Table 1.10).

Rubber is an export-oriented commodity, because most of the rubber produced in Indonesia supplies the international market. The amount of rubber exported in 2002 was 1.49 million tons, increasing to 2.35 million tons in 2010 (Table 1.11). The percentage of exported product out of total production was 91.8% in 2002 and 86% in 2010; therefore, the domestic demand is increasing. There has been increased activity of the rubber/plastic wares manufacturing sector, which is closely related to the rubber crop sector.

Indonesia exports natural rubber in five forms: (1) natural rubber latex, (2) RSS, (3) standard Indonesian rubber, the technically specified rubber produced by Indonesia, (4) other technically specified rubber, and (5) other natural rubber (Table 1.12). Standard Indonesian rubber (SIR) accounts for the largest proportion of these exported rubber types, because it is the easiest form to manufacture. Among the various SIR types, SIR 20, the lowest grade, is the main exported type. In international market, there is small price difference between SIR 10 and SIR 20, US$ 0.56/kg and US$ 0.52/kg, respectively in 2001; and US$ 1.21/kg and US$ 1.51/kg, respectively. However the percentage of SIR 20 exported remains largest among SIR type. This condition may raise question why the quality is still low.

1.4 Justification of Study

Rubber is the main crop for at least two million Indonesian farmers, and at least eight million people rely on this crop for their income. As well as providing employment for two million households, the rubber crop also generates gross domestic product (GDP). Rubber is a commercial crop that is strongly related to international demand. The rubber crop provides raw materials for other industries, both domestically and internationally. The domestic industry provides opportunities for employment and income, while international industries provide international currency that is necessary for national economic development. Several studies, both local and international, have focused on the low productivity of smallholder rubber farms and the low quality of their output. Previous studies have had a broad focus, rather than a detailed one. Therefore, the aim of this study is to focus in detail on the role of the rubber crop in the Indonesian economy and in providing income for farmers.

The aim of the present study is to provide a comprehensive and detailed overview of the rubber crop and rubber farming in Indonesia. “Comprehensive” means analyzing the rubber crop both in macro and micro conditions. “Detailed overview” means identifying the main problems in rubber farming, and describing them based on daily farm activities. The findings of this study will provide important baseline data for related research, and will be useful for policy makers in terms of the development of rubber farming in Indonesia.

1.5 Objectives

The main objective of this research is to explain the effects of improved technologies on the income of smallholder rubber farmers in Indonesia. The detailed objectives are as follows: (1) to describe the role of the rubber crop sector in Indonesian economic development; (2) to explain the general conditions of rubber farmers and their income; (3) to investigate the effects of improved technology on productivity and income and the constraints for applying improved technology; and, (4) to conduct an economic analysis of slab rubber quality.

The aim of objective 1 is to discuss the role of the rubber crop sector in the Indonesian economy based on its share of gross output, wages and salaries, and value-added. The rubber crop sector is included in the agricultural sector in the Indonesian economy. From 2000 to 2010, the role of agriculture in the Indonesian economy has decreased as the roles of manufacturing sectors have increased. However, it is still unclear whether the rubber sector has become more important or less important in the Indonesian economy, and especially within the agriculture sector.

The aim of objective 2 is to explain the general conditions of rubber farmers and their income. General conditions include land holding, education, number of family, while income includes income from rubber and other resources. In this context, rubber crops are compared with other crops such as paddy, maize, and palm oil. The main objective of farmers is to gain income from cultivating crops. Then, the farmers use their income to purchase goods.

The aim of objective 3 is to discuss the role of improved technology in increasing the productivity and income of rubber farmers. In this context, improved technologies include the cultivation of high-yield varieties (HYV), applications of fertilizers, stimulants, and pesticides, and controlling weeds. However, the costs of these technologies make them inaccessible to smallholder rubber farmers. Then, the question is how to enable farmers to adopt improved technologies to increase productivity and income.

The aim of objective 4 is to conduct an economic analysis of slab rubber quality. One way to increase income is to produce better-quality slab rubber at the farm level. To this end, the local government in South Sumatra has introduced new technology, that is, applying a permitted coagulant to process slab rubber. Also, the government has subsidized the cost of the permitted coagulant, which increases the quality of slab rubber. Hypothetically, farmers will produce better-quality rubber if they get a higher revenue from it.

1.6 Data

To meet the objectives of this study, primary data, secondary data, and case study data were collected and analyzed. To meet the aims of objective 1, the role of the rubber crop sector in Indonesian economic development was considered based on data in the Indonesian input–output tables 1995 and 2005, which were issued by Statistic Indonesia (1999, 2007). To meet the aims of objective 2, the general conditions of rubber farmers and their income were evaluated based on primary data from the Survei Pendapatan Petani 2004 (Farm Income Survey 2004; Complement of Agricultural Census, 2003) and the Survei Sosial Ekonomi Nasional (Social–Economic National Survey, 2005) from Statistic Indonesia (2004b, 2005b).

To meet the aims of objective 3, the effects of improved technology on productivity and income were considered based on farm record data collected in field surveys. Finally, for objective 4, the quality of rubber produced by smallholder rubber farmers was evaluated in a specific case study.

The field work related to objectives 3 and 4 was conducted in Plajau Ilir Village, Banyuasin III Sub District, Banyuasin District, South Sumatra Province, one of the rubber-producing centers in Indonesia. The research area is located 64 km west of Palembang, the provincial city of South Sumatra (Figure 1.2). This region was selected because some farmers in the village apply new technologies to cultivate rubber, and some farmers produce better-quality slab rubber.

1.7 Organization of Thesis

This research explains the effect of improved technologies on the income of smallholder rubber farmers in Indonesia. The introduction (Chapter 1) explains the importance of Indonesian natural rubber in the global market, and briefly outlines the role of natural rubber farming in the Indonesian economy, the conditions of rubber farming in Indonesia, and the main problems related to rubber farming in Indonesia. The role of the rubber sector in economic development is discussed in Chapter 2. This chapter explains in detail the contribution of the rubber crop sector to total gross output, total wages and salaries, and the total value-added. The position of the rubber crop is compared with those of other crops in the agricultural sector such as paddy, vegetables and fruit, and palm oil.

Chapter 3 discusses the general conditions of rubber farmers in Indonesia, including their demographic conditions, income, and household consumption.

Chapter 4 describes the effects of improved technology on productivity and income. The term “improved technology” includes the cultivation of new, high-yielding varieties, application of fertilizers, pesticides, and stimulants, and weed control. This chapter compares production inputs between farmers who apply improved technology and those who do not. More production inputs may result in higher productivity and higher income. This chapter explains production inputs and outputs in detail, based on analyses of daily farm record data, and explains how smallholder rubber farmers apply improved technology, and gives some of the difficulties.

Chapter 5 describes an economic analysis of slab rubber quality. To produce better-quality rubber, farmers may have to pay higher processing costs. The discussion starts with a definition of slab rubber quality based on the national standard, then describes how farmers process and sell slab rubber at present. The costs related to, and income from, poor-quality and better-quality rubber products are compared. This chapter also outlines various scenarios that could result in improved slab rubber quality. As comparison, one farmer who produces premium quality is described. Besides, the possible way to improve rubber quality also proposed.

Finally, the summary outlines the conclusions and policy recommendations based on this research. This section summarizes the importance of this study, how it was conducted, the objectives, and the answers to the questions posed based on analyses of statistical, survey, census, and field data. Then, each of the objectives is discussed based on data, real conditions, and theory. Finally, several recommendations to improve the income of smallholder rubber farmers in Indonesia are proposed.

Table 1.1 Global exports of natural rubber by country in 2001 and 2010.

Country	2001		2010	
Thailand	2,042	(40)	2,866	(36)
Indonesia	1,497	(29)	2,369	(29)
Malaysia	162	(3)	1,245	(15)
Vietnam	283	(6)	782	(10)
Côte d'Ivoire	124	(2)	247	(3)
Guatemala	33	(1)	76	(1)
Myanmar	29	(1)	67	(1)
Liberia	107	(2)	62	(1)
Cameroon	60	(1)	58	(1)
Sri Lanka	32	(1)	57	(1)
Others	738	(14)	211	(3)
Total	5,107	(100)	8,041	(100)

Source: International Rubber Study Group (2012b).
Notes: Numbers in parentheses are percentages of total in each column.
Values are 000 ton.

Table 1.2 Global natural rubber production, area, and yield.

Country	Production[a]				Area[b]				Yield/ha[c]	
	2001		2010		2001		2010		2005	2008
Thailand	2,522	(35)	3,051	(30)	1,504	(19)	1,929	(20)	1,736	1,699
Indonesia	1,607	(22)	2,735	(27)	2,599	(33)	3,445	(36)	862	993
Malaysia	882	(12)	900	(9)	1,250	(16)	1,112	(12)	959	1,411
India	631	(9)	862	(8)	401	(5)	477	(5)	1,726	1,903
Vietnam	312	(4)	752	(7)	241	(3)	438	(5)	1,442	1,654
China	477	(7)	690	(7)	416	(5)	577	(6)	1,083	1,077
Sri Lanka	86	(1)	153	(1)	157	(2)	124	(1)	1,144	1,380
Others	774	(11)	1,143	(11)	1,422	(18)	1,351	(14)	-	-
Total	7,293	(100)	10,287	(100)	7,990	(100)	9,454	(100)	-	-

Source: Food and Agriculture Organization (2011) and Association of Natural Rubber Countries (2010).
Notes: [a]Values are 000 ton. [b]Values are 000 ha. [c]Values are kg/ha.
Numbers in parentheses are percentages of total in each column.

Table 1.3 Value of global rubber exports from 2001 to 2010.

Year	Natural rubber		Synthetic rubber		Total	
	(1)		(2)		(3)=(1)+(2)	
2001	3,360	(36)	6,037	(64)	9,397	(100)
2002	4,394	(41)	6,301	(59)	10,695	(100)
2003	6,583	(47)	7,327	(53)	13,910	(100)
2004	8,747	(49)	9,197	(51)	17,944	(100)
2005	9,954	(46)	11,463	(54)	21,417	(100)
2006	15,131	(53)	13,390	(47)	28,522	(100)
2007	16,369	(52)	15,373	(48)	31,742	(100)
2008	19,896	(52)	18,223	(48)	38,119	(100)
2009	11,937	(46)	13,773	(54)	25,711	(100)
2010	24,818	(55)	20,196	(45)	45,014	(100)

Sources: International Trade Center (2011).
Notes: Values are US$ million.
Numbers in parentheses are percentages of total in each row.

Table 1.4 World consumption of natural rubber by country.

Year	2001		2010	
China	1,215	(16)	3,646	(34)
India	631	(9)	944	(9)
U.S.A.	974	(13)	926	(9)
Japan	729	(10)	749	(7)
Thailand	253	(3)	459	(4)
Malaysia	330	(4)	458	(4)
Indonesia	142	(2)	421	(4)
Rep. of Korea	332	(4)	384	(4)
Brazil	216	(3)	377	(3)
Germany	246	(3)	291	(3)
Others	2,031	(28)	2,413	(22)
Total	7,381	(100)	10,783	(100)

Source: International Rubber Study Group (2012a).
Notes: Values are 000 ton.
Numbers in parentheses are percentages of total in each column.

Table 1.5 Exports of main estate crop products and proportion of Indonesian total exports in 2000 and 2010.

Sector	2000		2010	
Palm oil	1,087	(2)	13,469	(9)
Rubber	912	(1)	7,354	(5)
Coffee	319	(1)	814	(1)
Cocoa	337	(1)	1,636	(1)
Others	59,469	(96)	134,506	(85)
Total export	62,124	(100)	157,779	(100)

Source: Statistic Indonesia (2011a).
Notes: Numbers in parentheses are percentage of total in each column.
Values are US$ million.

Table 1.6 Share of wages and salaries of agriculture sectors out of total national wages and salaries in 1995 and 2005.

Sector	Code	Wages and salaries[a]		Share of income[b]	
		1995	2005	1995	2005
Paddy	1	3,546,201	10,726,885	2.2	1.2
Beans	2	369,389	1,264,219	0.2	0.1
Maize	3	455,517	2,632,224	0.3	0.3
Root crops	4	430,574	2,150,301	0.3	0.2
Vegetable and fruit	5	2,100,066	13,689,632	1.3	1.6
Other food crops	6	7,241	130,628	0.0	0.0
Rubber	7	1,584,450	8,420,393	1.0	1.0
Sugarcane	8	1,022,294	1,606,000	0.6	0.2
Coconut	9	490,418	1,485,126	0.3	0.2
Palm oil	10	486,364	3,869,564	0.3	0.4
Tobacco	11	339,298	423,420	0.2	0.0
Coffee	12	235,176	1,492,157	0.1	0.2
Tea	13	189,681	221,331	0.1	0.0
Clove	14	116,548	410,986	0.1	0.0
Fiber crops	15	51,115	37,375	0.0	0.0
Other estate crops	16	282,762	1,448,876	0.2	0.2
Other agriculture	17	435,882	2,311,205	0.3	0.3
Livestock	18	998,898	4,137,595	0.6	0.5
Slaughtering	19	1,415,049	4,627,723	0.9	0.5
Poultry and its products	20	721,225	11,886,538	0.4	1.3
Wood	21	1,287,073	3,781,791	0.8	0.4
Other process products	22	192,759	985,376	0.1	0.1
Fishery	23	1,700,784	11,616,810	1.0	1.3
Non-agricultural sectors	24-66	144,917,638	792,861,830	88.7	89.9
Total		163,376,402	882,217,985	100.0	100.0

Source: Statistic Indonesia (1999, 2007).
Notes:
Sector 1 – sector 6 = food, vegetable and fruit sector.
Sector 7 – sector 16 = estate sectors.
Sector 17 – sector 20 = livestock sectors.
Sector 21 – sector 22 = forestry sectors.
Sector 23 = fisheries sectors.
[a]Values are million Rupiahs.
[b]Values are percentage.

Table 1.7 Income of each agricultural sub-sector and its proportion of the total agricultural sector in 2004.

Income source	Income[a]	Share[b]
Paddy wetland	258,400,971	18.1
Fisheries	176,997,924	12.4
Rubber	169,723,099	11.9
Palm oil	83,141,702	5.8
Cocoa	73,947,092	5.2
Coconut	65,855,029	4.6
Cow (livestock)	52,218,501	3.7
Maize	51,965,436	3.6
Coffee	41,094,768	2.9
Paddy upland	36,792,890	2.6
Others	415,351,230	29.1
Total	1,425,488,642	100.0

Source: Statistic Indonesia (2004b).
Note: [a]Values are thousand Rupiahs.
[b]Values are percentage.

Table 1.8 Rubber production, rubber cultivation area, and types of rubber producers in Indonesia in 2002 and 2011.

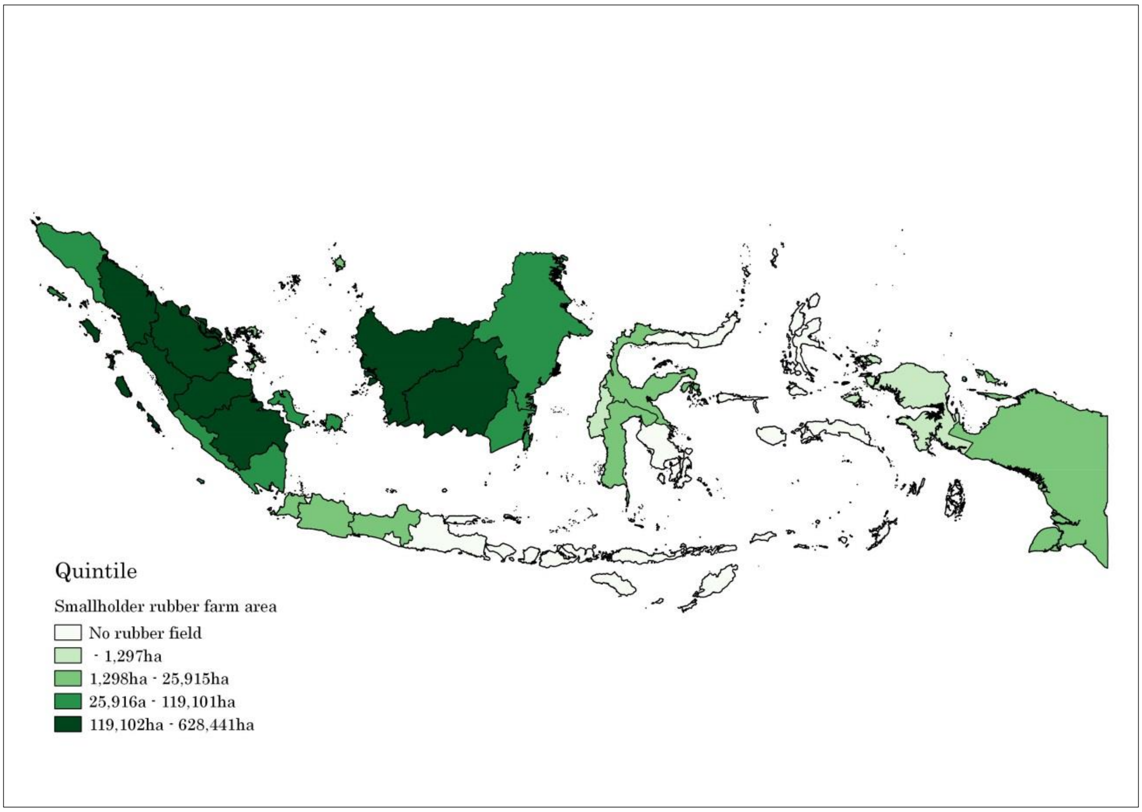
Category of producer	Area[a]				Production[b]			
	2002		2011		2002		2011	
Smallholders	2,825,476	(85)	2,931,844	(85)	1,226,647	(75)	2,486,023	(80)
Government plantations	221,228	(7)	257,005	(7)	186,535	(11)	285,988	(9)
Private plantations	271,655	(8)	267,278	(8)	217,177	(13)	316,416	(10)
Total	3,318,359	(100)	3,456,127	(100)	1,630,359	(100)	3,088,427	(100)

Source: Statistic Indonesia (2002, 2011b).
Notes: [a]Values are ha. [b]Values are ton.
Numbers in parentheses represent percentage of total in each column.

Table 1.9 Rubber production areas in main islands of Indonesia in 2002 and 2010.

No	Province	Smallholder		Government plantation		Private plantation	
		2002	2010	2002	2010	2002	2010
1	Jawa	21,211	26,587	55,754	69,021	43,985	42,301
		(1)	(1)	(25)	(27)	(16)	(18)
2	Sumatera	2,022,618	2,115,530	131,887	142,758	182,883	169,161
		(75)	(72)	(60)	(55)	(67)	(71)
3	Kalimantan	632,358	785,172	27,743	43,316	34,075	18,986
		(23)	(27)	(13)	(17)	(13)	(8)
4	Bali and Nusa Tenggara	-	-	-	-	102	530
		(0)	(0)	(0)	(0)	(0)	(0)
5	Sulawesi and East Indonesia	16,513	21,456	5,844	4,405	10,610	6,192
		(1)	(1)	(3)	(2)	(4)	(3)
	Total	2,692,700	2,948,745	221,228	259,500	271,655	237,170

Source: Statistic Indonesia (2002, 2011b).
Notes: Values are ha.
Numbers in parentheses represent percentage of total in each column.



Source: Statistic Indonesia (2011b), Badan Informasi Geospasial (2005).

Figure 1.1 Map showing density of smallholder rubber farms in Indonesia, 2010.

Table 1.10 Productivity of rubber producers in Indonesia in 2002 and 2011.

No	Category producer	2002[a]	2011[a]	Growth[b]
1	Smallholder	617	1,036	68
2	Government plantation	1,045	1,509	44
3	Private plantation	1,298	1,553	20

Source: Statistic Indonesia (2002, 2011b).
Note: [a]Values are kg/ha. [b]Values are percentage.

Table 1.11 Total rubber production, rubber exports, and domestic use of rubber in Indonesia from 2002 to 2010.

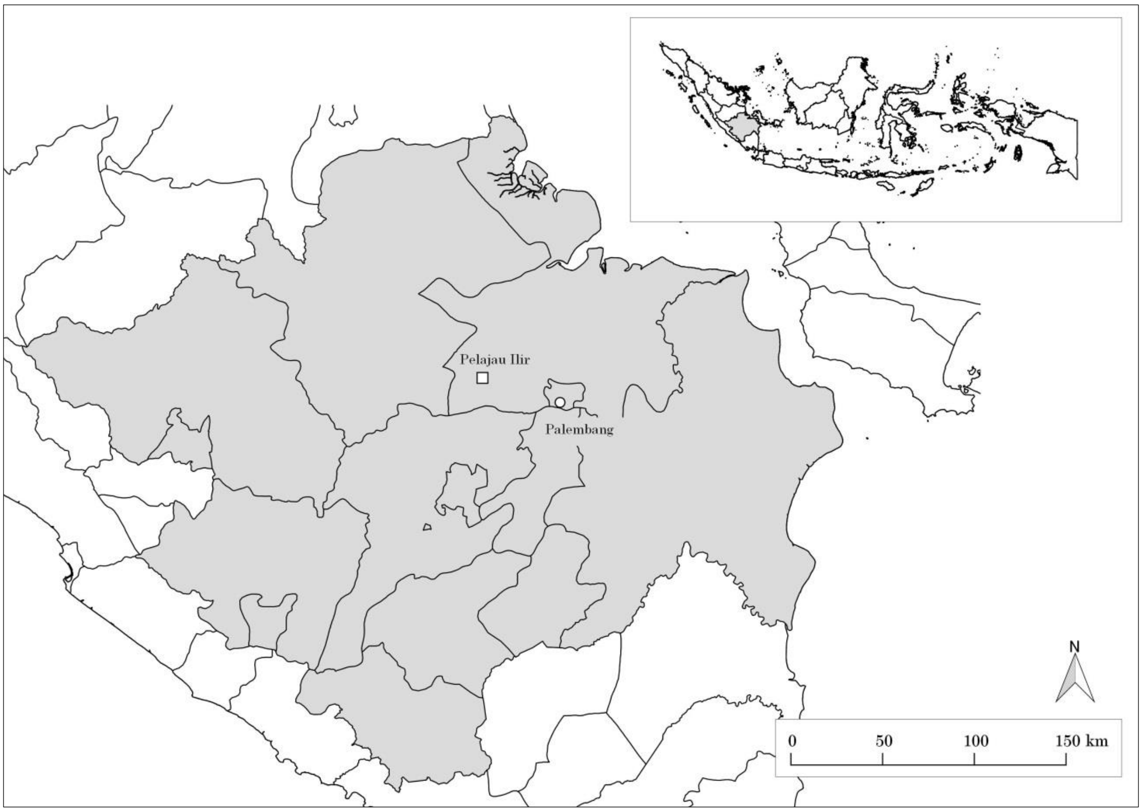
Year	Export[a]	Production[a]	Domestic use[a]	Share[b]
2002	1,496,381	1,630,359	133,978	91.8
2003	1,661,972	1,792,348	130,376	92.7
2004	1,875,061	2,065,816	190,755	90.8
2005	2,024,608	2,270,891	246,283	89.2
2006	2,287,053	2,637,231	350,178	86.7
2007	2,407,849	2,755,172	347,323	87.4
2008	2,295,456	2,751,286	455,830	83.4
2009	1,991,263	2,440,347	449,084	81.6
2010	2,350,640	2,734,854	384,214	86.0
Average	2,043,365	2,342,034	298,669	87.7

Source: Statistic Indonesia (2002, 2004a, 2005a, 2011b).
Notes: [a]Values are ton, [b]Values are in percentage.

Table 1.12 Exports of Indonesian natural rubber by type and grade in 2001 and 2004.

Type and grade	2001				2004			
	Value[a]	Quantity[b]	Share[c]	Price[d]	Value[a]	Quantity[b]	Share[c]	Price[d]
Natural rubber latex	7.18	10.37	(0.7)	0.69	12.47	11.1	(0.6)	1.12
Rubber smoked sheets	19.9	32.68	(2.2)	0.61	170.15	145.89	(7.8)	1.17
SIR								
SIR 3 CV	22.22	32.05	(2.2)	0.69	137.39	116.15	(6.2)	1.18
SIR 10	33.51	59.73	(4.1)	0.56	38.88	32.25	(1.7)	1.21
SIR 20	666.41	1,273.21	(87.6)	0.52	1,760.48	1,524.43	(81.4)	1.15
Other SIR	26.02	38.7	(2.7)	0.67	9.36	7.36	(0.4)	1.27
Other TSR	2.04	0.67	(0.0)	3.04	33	26.92	(1.4)	1.23
Other natural rubber	8.91	5.98	(0.4)	1.49	17.28	9.5	(0.5)	1.82
Total		1,453.39	(100.0)			1,873.60	(100.0)	

Source: Statistic Indonesia (2002, 2005a).
Notes: [a]Values are million US$. [b]Values are 000 ton. [c]Values are percentage. [d]Values are US$.
Numbers in parentheses represent percentage of total in each column.
Price is calculated from the ratio of value to quantity.



Source: Badan Informasi Geospasial (2005).

Figure 1.2 Research area.

Chapter 2
Role of the Rubber Crop Sector in Indonesian Economic Development

2.1 Introduction

The rubber industry is one of the major progressive sectors contributing to the Indonesian economy. The share of the sector, in terms of export value, more than tripled within a decade, from 1.47% in 2000 to almost 4.66% in 2010 (Statistic Indonesia, 2011a), indicating that the rubber industry has achieved well over this decade. Export includes two related sectors: the rubber crop sector, which produces raw materials (latex, cup lump, and slab rubber) and the rubber manufacturing sector, which processes raw material into other rubber products. The former is part of the agricultural sector, and the latter is part of the manufacturing sector.

The rubber crop sector has specific demands that differ from those of other agricultural crop sectors. The demand comes from the domestic rubber manufacturing sector. Similarly, the domestic rice milling sector has strong demands on the paddy crop sector. There is also international demand for the rubber crop, similar to the palm oil crop. Like other agricultural sectors, the rubber crop sector requires production inputs from other sectors. However, the level on input differs from that required by other agricultural crops.

In the last decade, the role of the agricultural sector has decreased as those of other sectors, such as the manufacturing and trading sectors, have increased. In 2001, agriculture contributed 16% of GDP, but only 13% in 2010. In contrast, the contribution of the transportation and communication sector increased from 5% in 2000 to 9% in 2010 (Statistics Indonesia, 2001-2011) (Table 2.1). Such changes may affect the roles of other sectors, including the rubber crop sector. Therefore, investigating the changes in the role of the rubber crop sector over time will provide a useful explanation of its role from a development perspective.

This chapter covers the role of the rubber crop sector in Indonesian economic development, particularly in the agricultural sector. Also, the role of the rubber crop sector is compared with those of other sectors, including the palm oil, paddy, and vegetable and fruit sectors. In detail, this chapter describes (1) the share of the rubber crop sector in gross output, wages and salaries, and value-added; (2) the backward and forward linkages of the rubber crop sector; and (3) the multiplier effects of gross output, wages and salaries, and value-added.

2.2 Input–Output Analysis in Economic Development

The input–output concept is a useful approach to explain the role of a sector in the economy. An input–output table was first used in 1936, when Wassily Leontief used it to analyze the United States economy in 1919 and 1929 (Wassily Leontief, 1936). Since then, input–output tables have been used to analyze the economies of 90 countries worldwide (United Nations, 1999). An input–output table provides macroeconomic data at national or regional levels.

In general, an input–output table reflects all of the economic sectors in a country. The table has three main parts: input transaction, primary input (gross value-added), and final demand (Chenery and Watanabe, 1958). In detail, the intermediate input represents the interrelationships among economic sectors; gross value-added represents wages and salaries, taxes and subsidies, and revenue; and final demand reflects final consumption, government expenditure, gross private capital, and net export.

The table can be analyzed in several ways: multiplier effects, backward and forward linkage analysis, structural accounting matrix analysis, structural decomposition analysis, and total factor production analysis. Which analyses are used depends on the research objectives and data availability.

An input–output table is a very useful framework to identify relationships among sectors in a country's economic structure. A backward and forward linkage analysis was first used by Rasmussen (1956) to analyze relationships among sectors. The sector with strong backward and forward linkages was categorized as a key sector (Hirschman, 1958). "Backward linkage" refers to the interconnectedness of the j sector to "upstream" sectors whose goods are used as inputs to produce the j sector; "forward linkage" explains the interconnection of a particular sector to those "downstream" sectors that buy its outputs (Miller and Blair, 2009). The backward and forward linkages are measured by indices.

Indices greater than 1 indicate that the sector plays an important role in economic development, whereas those smaller than 1 indicate that the sector is not a key sector (Miller and Blair, 2009).

Backward and forward linkage analyses have been used by several researchers in various economic fields. They have been used, for example, to evaluate the role of four electric power sectors in the Korean national economy (Han et al., 2004); to analyze inter-industry linkages in the mining industry in the European Union (Cristobal and Biezma, 2006); to evaluate tourism and economic growth in Turkey (Atan and Arslanturk, 2012); and to assess the role of capture fisheries and aquaculture sectors in the Korean national economy (Lee and Yoo, 2014).

As reported by Liu et al. (1984), multipliers measure the effect of exogenous spending in the economy by adding up all the successive rounds of respending. This is one of the advantages of an input–output table, in that it contains information on changes in exogenous variables in an economic model (Miller and Blair, 2009). Changes in the final demands (household consumption expenditure, government expenditure, gross fixed capital, and export) of a sector directly affect that sector and indirectly affect the sectors related to it.

There are several types of multiplier effects: output, income, employment, and value-added (Miller and Blair, 2009). The first three are traditional economic multipliers (Hsu, 1989). An output multiplier can be explained as follows: a one unit increase in the final demand for sector i will increase the output of sector i by a value of the multiplier (direct effect) and will increase the output of other related sectors (indirect effect). Then, multiplier income means an additional unit of final demand for the output of sector i would generate household income by the value of the multiplier corresponding to sector i and other related sectors. The same definition applies to the employment multiplier, except that additional employment data are included.

Multiplier effect analyses provide useful information for policy makers and planners (Archer, 1982), and have been applied in many sectors. For example, a multiplier effect analysis was used to evaluate the tourist sector in Turkey (Liu et al., 1984). In another study, a multiplier effect analysis was used to evaluate the role of the marine sector in the Irish national economy (Morrissey and O'Donoghue, 2013), and to evaluate whether a proposed marine development project should be undertaken.

2.3 Data and Analytical Methods

This chapter uses input–output tables published by Statistic Indonesia every five years. To understand the role of the rubber sector over the last decade, Indonesian input–output tables 1995 and 2005 (the 2005 version being the latest table released by the Statistic Indonesia) were included in the analysis. The data in the tables are based on domestic transactions at producer prices for 66 sectors. In the tables, the rubber industry comprises two related sectors: the rubber crop sector (code 7) and the rubber/plastic ware manufacturing sector (code 42). In this chapter, the focus is on the rubber crop sector, code 7.

The role of the rubber crop in the Indonesian economy is explained as follows: (1) by assessing the share of the sector relative to total gross output, wages and salaries, and value-added; (2) by analyzing its backward and forward linkages to other sectors; and (3) by the multiplier effect of the sector to gross output, wages and salaries, and value-added. The discussion explains the position of rubber sector relative to those of the 66 sectors in the Indonesian economy, the 23 agricultural sectors, and the 10 estate sectors. Specifically, the rubber crop sector is compared with the palm oil, paddy, and vegetable and fruit sectors. The palm oil sector represents a estate sector, the paddy sector represents a staple food sector, and the vegetable and fruit sector represents a complementary food sector.

The analysis starts with a general figure of the input–output relationships in an economy. An economy can be divided into *n* sectors, and can be represented using the following equation (Miller and Blair, 2009, p.11):

$$x_i = z_{i1} + \cdots + z_{in} + f_i = \sum_{j=1}^{n} z_{ij} + f_i \qquad (2.1)$$

where x_i is the total output of sector i, z_{ij} is the interindustry sales by sector i to sector j, and fi is the final demand for sector i.

The final demand vector represents consumer (household) purchases, C; purchases for (private) investment purposes, *I*; government (federal, state, and local) purchases, G; and sales abroad (exports), E. Together, the first three $(C+I+G)$ represent domestic final demand and E represents foreign final demand. Therefore, the total gross output of the economy, X, can be defined as follows:

$$X = x_1 + \cdots + x_n + C + I + G + (E - M) \tag{2.2}$$

therefore, the share of the total output of sector *i* can be defined as the ratio of the total output from sector i to the total gross output.

To produce an output from sector i, inputs from other sectors are required, as well as employees, tax payments, operating surplus, depreciation, indirect tax, and subsidies. In an economic context, an employee receives a wage or salary (L) as compensation for the time spent working; entrepreneurs receive profit for conducting business, interest for capital, and rent for land (P). Entrepreneurs also face depreciation (D) for their investment, households pay tax (T), and some businesses receive subsidies (S). All of these factors are summarized as value-added. In an input–output table, total gross output, X, is calculated as follows:

$$X = x_1 + \cdots + x_n + L + P + D + T + X + S \tag{2.3}$$

Therefore, the share of wages and salaries is the ratio between the wages and salaries for sector i to wages and salaries for the whole sector. The share of value-added is defined as the ratio between value-added of sector i and that of the whole sector.

To define a backward and forward analysis, equation (2.1) is redefined as follows:

$$x = A_x + f \tag{2.4}$$

where x is the total output, f is the final demand, and A is the matrix of input coefficients. A is defined as the ratio between the intermediate demand for input between sector i and total output of the sector, calculated as follows:

$$A = a_{ij} = \frac{z_{ij}}{x_{ij}}$$

Equation (2.4) can be rearranged as follows:

$$\mathrm{x} = (\mathrm{I} - \mathrm{A})^{-1}\mathrm{f} \tag{2.5}$$

where $(I = A)^{-1}$ is the Leontief inverse matrix. There are several types of Leontief inverse matrix (Kuboniwa, 1989). Because this study focuses on domestic demand, we used a competitive import-type input–output table with this inverse matrix:

$$B = \left[I - (I - \widehat{M})A\right]^{-1} \tag{2.6}$$

where A is the n-by-n matrix of input, I is the identity matrix, and $\widehat{M}$ is the diagonal matrix (mi). The $\widehat{M}$ is an n-by-n diagonal matrix whose diagonal element *mi* denotes the ratio commodity i's import to sector i's domestic demand (intermediate input plus domestic final demand, domestically produced and imported). Backward linkage is the column summarizing the inverse matrix, whereas forward linkage is the row summarizing the inverse matrix.

By applying the competitive import model, the total output can be defined as follows:

$$x = \left[I = (I - \widehat{M})A\right]^{-1} f \tag{2.7}$$

To determine the effects of a change in final demand on output, wage and salary, and value-added, output multiplier, wage and salary multiplier, and value-added multiplier values are applied as follows:

$$l_{ij} = \left[I - (I - \widehat{M})A\right]^{-1}$$
$$m(o)_j = \sum_{i=1}^{n} l_{ij} = \text{multiplier of output,} \tag{2.8}$$

where $m(o)_j$ means that a one Rupiah increase in the final demand for sector j directly affects the output of sector i and indirectly affects other sectors. In practice, the higher the value of the output multiplier, the greater the effect of the sector on the economy.

The wage and salary multiplier is obtained by multiplying of coefficient of wages and salaries for each sector by the inverse matrix:

$$m(h)_j = \sum_{i=1}^{n} h_i l_{ij} \tag{2.9}$$

where $m(h)_j$ is the income multiplier in sector j, h_i is the wages and salaries coefficient of sector i, and l_{ij} is the Leontief inverse matrix, as shown in equation (2.8).

The value of the wage and salary multiplier indicates how final demand affects household income. That is, an additional one rupiah of final demand for sector i would generate new household wage and salary by the value of the wage and salary multiplier. This multiplier explains the direct and indirect effects of an increase in the final demand for a sector.

Finally, the value-added multiplier determines the effect of final demand on the value-added portion of a sector. Value-added includes wages and salaries, operating surpluses, depreciation, indirect taxes, and subsidies. The value-added multiplier can be calculated as follows:

$$m(va)_j = \sum_{i=1}^{n} va_i l_{ij} \tag{2.10}$$

where $m(va)_j$ is the multiplier of value-added sector j, va_i is the value-added coefficient i, and l_{ij} is the Leontief inverse matrix shown in equation (2.8).

2.4 Share of Rubber Crop Sector in Indonesian Economic Development

This chapter evaluates the role of the rubber crop sector in Indonesian economic development from 1995 to 2005. First, the share of the rubber sector in the Indonesian economy is discussed by explaining its share of gross output, wages and salaries, and value-added to total gross output, total wages and salaries, and total value-added. Second, the results of backward and forward linkage analyses are discussed, to understand how the rubber crop sector attracts and pushes other economic sectors. Finally, the multiplier effects are described to explain the effects of final demand on output, wages and salaries, and value-added. The position of the rubber crop sector in the Indonesian economy, especially in the agricultural and estate sectors is described. Also, the rubber crop sector is compared with other sectors such as the palm oil, paddy, and vegetable and fruit sectors.

The share of the rubber sector in Indonesian economic development is explained based on its share of gross output, wages and salaries, and value-added. The gross output of a sector is the total product of a sector per year, minus imports from overseas. The sector's share of total output can explain which sectors make the largest contributions to the economy, and which make the smallest contributions. The share of wages and salaries indicates the contribution of the rubber crop sector to total wages and salaries. The share of value-added indicates the contribution of the rubber crop sector to total value-added. Value-added includes wage and salary, operating surplus, depreciation, indirect tax, and subsidies.

The results of the analysis showed that in 1995, the rubber crop accounted for 0.38% of the total Indonesian economic output, ranking 49th out of 66 sectors. This is a small proportion of total gross output, but relatively large among the agricultural sectors. The rubber crop sector ranked 10th out of 23 agricultural sectors, and 2nd out of 10 estate sectors (Table 2.2). The rubber crop sector accounted for a smaller proportion of total output than did the paddy sector (2.37%) and the vegetable and fruit sectors (1.62%), but a greater proportion than did the palm oil sector (0.28%). This might be because of differences in the number of households engaged in these sectors.

In 2005, the rubber crop accounted for 0.41% of the total Indonesian economic output, ranking 43rd out of 66 sectors. This represented a slight increase (0.03%) since 1995. As shown in Table 2.2, the shares of most agricultural sectors decreased from 1995 to 2005, except for maize, palm oil, and fisheries. The increase in the share of the rubber crop sector showed that this sector evolved over that decade, via an increase in the volume and/or price of its output.

In 1995, the share of wages and salaries of the rubber crop sector was 0.97%, ranking 24th out of 66 sectors in the Indonesian economy, 4th out of 23 agricultural sectors, and 1st out of 10 estate crop sectors. This proportion was smaller than those of the paddy sector vegetable and fruit sectors, but higher than that of the palm oil sector. Therefore, the rubber crop sector accounted for a higher proportion of total wages and salaries than did the other estate sectors. In 2005, the share of rubber crop wages and salaries had slightly decreased to 0.95%, ranking 31st out of 66 sectors, 5th out of 23 agricultural sectors, and 1st out of 10 estate sectors. Therefore, the rubber crop sector accounted for the largest proportion of wages and salaries among the estate sectors (Table 2.2).

Another measurement is value-added, which includes wage and salary operating surplus, depreciation, indirect tax, and subsidies. The higher the share of a sector in value-added, the greater its contribution to the economy. In 1995, the rubber sector accounted for 0.50% of total value-added, ranking 47th out of 66 sectors, 12th out of 23 agricultural sectors, and 2nd out of 10 estate crop sectors (Table 2.2). This value indicates that the rubber sector makes large contributions to the farmers (entrepreneurs) who run the business, and to the government, which receives indirect tax from this sector. This contribution was lower than those of the paddy sector and vegetable and fruit sector, but higher than that of the palm oil sector. Ten years later in 2005, the contribution of the rubber crop sector to value-added had slightly increased to 0.57%, ranking 38th out of 66 sectors, 8th out of 23 agricultural sectors, and 1st out of 10 estate sectors. Therefore, the rubber sector became the main contributor to value-added in the estate crop sector.

In summary, the share of the rubber crop sector in Indonesia's economy is low, but it makes up a larger share of the agricultural sector, especially the estate crop sectors. From 1995 to 2005, the share of the rubber crop sector in output and value-added increased, but the share of wages and salaries decreased (Table 2.5a). Therefore, there is an increasing trend in the output and value-added parts of the rubber crop sector, but the wages and salaries of workers in the rubber crop sector are decreasing.

The allocation of output describes whether it meets domestic or international demands. The domestic demand includes private expenditure, government expenditure, capital investment, and changes in inventory. If an output is allocated to domestic demand, the demand may be from either final consumption or intermediate demand. Therefore, a sector whose output meets intermediate demand may be closely related to other economic sectors. If the output of a sector is allocated to export demand, the sector earns foreign currency, which is important for international trading.

In 1995, 49% of the output of the rubber sector was allocated to fulfill private domestic consumption, and 35% to fulfill international demand. The domestic demand was from the rubber-manufacturing sector. For comparison, the palm oil sector allocated 67% of its output to fulfill domestic demand and 29% to fulfill international demand, and the paddy sector (sector 1) allocated 98% of its output to fulfill private domestic consumption as raw material for the rice milling sector. The vegetable and fruit sector (sector 5) allocated 97% of its output to meet domestic final demand (Figure 2.3). Sectors whose outputs are allocated to fulfill domestic demand as the raw material for other sectors contribute more to the economy than do sectors that allocate their outputs to private expenditure and export. However, when the outputs are allocated to export, the sector earns overseas currency, which is important for economic development.

In 2005, 44% of the output of the rubber sector was allocated to fulfill domestic demand and 40% to fulfill export demand. This shift means that the rubber crop sector made a greater contribution to foreign currency reserves over this decade. However, the increase in exports did not affect domestic wages and salaries, and value-added. Similarly, the output of the palm oil crop sector had shifted dramatically from fulfilling domestic demand to fulfilling export demand. However, the paddy sector and vegetable and fruit sector still allocated most of their outputs to domestic demand.

2.5 Backward and Forward Linkages of the Rubber Crop Sector

Backward and forward linkages reveal the relationships among sectors in an economy. Sectors with higher linkage indices play a larger role in the economy. The backward linkage index indicates the ability of a sector to attract other sectors as production inputs, whereas the forward linkage index indicates the ability of a sector to provide inputs to other sectors.

The analysis showed that among 23 agricultural sectors, most have backward and forward indices lower than 1, except for paddy, sugarcane, tobacco, slaughtering, and poultry sectors. Therefore, most agricultural sectors have low backward and forward linkages (Table 2.3). That is, most agricultural sectors (except paddy, sugarcane, tobacco, slaughtering, and poultry) have low dependency on other sectors. Sectors categorized as independent sectors are those that meet private expenditure (final consumption) or are export-oriented.

The rubber crop sector is categorized as an independent sector (In) in the Indonesian economy. That is, it has a low ability to attract other sectors as production inputs and a low ability to provide inputs to other sectors. A low backward linkage index does not mean that the rubber sector applies a low level of production inputs, rather that its contribution is lower than those of other sectors. Similarly, a low forward linkage index does not mean that the rubber sector does not push other sectors, rather that its contribution is lower than those of other sectors. The paddy sector has a low backward linkage index but a higher forward linkage index; consequently, it is categorized as dependently demanded (DD). This means it has a low ability to attract inputs from other sectors, but its output strongly pushes the rice milling sector. The vegetable and fruit sector has a low ability to attract inputs from other sectors and also a low ability to push other sectors, because most of its output (97%) meets domestic demand. Consequently, it is categorized as an independent sector. The palm oil sector has low backward and forward linkage indices, and so it is also categorized as an independent sector. Different from the paddy sector, the palm oil sector fulfills international demand. Therefore, it has a low forward linkage index.

In the backward and forward linkage analysis, the rubber crop sector was categorized in the independent category. The analysis showed that its ability to attract more inputs is lower than that of the paddy sector, but the same as that of the palm oil sector. The rubber crop sector also has a low ability to push other sectors. From 1995 to 2005, the backward linkage index of the rubber crop sector slightly decreased, while the forward linkage index increased. This means that the rubber crop sector became better able to support further sectors such as rubber/plastic manufacturing (Table 2.5b).

2.6 Multipliers of the Rubber Crop Sector

The two previous sub-chapters have discussed the role of rubber sector in gross output, wages and salaries, and value-added, and the role of the rubber sector to attract and push other sectors in the economy. The next focus is the effect of final demand on the output, wages and salaries, and value-added components of the rubber sector.

In 1995, the multiplier of wages and salaries of the rubber crop sector was 1.36, ranking 45th out of 66 Indonesian economic sectors, 7th out of 23 agricultural sectors, and 4th out of 10 estate sectors. That means that an increase of Rp 1 in final demand would increase output by Rp 1.36. This value was higher than that of the paddy sector and the vegetable and fruit sector, but lower than that of the palm oil sector. By 2005, the value of this multiplier had increased to 1.39. This does not necessarily mean that increasing final demand will increase production, but there is a positive signal in terms of either production or price within a decade.

In 1995, the multiplier of wages and salaries for the rubber crop sector was 0.02, ranking 37th out of 66 Indonesian economic sectors, 3rd out of 23 agricultural sectors, and 1st out of 10 estate sectors (see Table 2.4). This means that an increase of Rp 1 in the final demand will increase the wages and salaries in the rubber sector by Rp 0.02. This value was higher than those of the palm oil sector and the vegetable and fruit sector, but lower than that of the paddy sector. In 2005, the multiplier of wages and salaries of the rubber sector was 0.02, ranking 48th out of 66 Indonesian economic sectors, 7th out of 23 agricultural sectors, and 2nd out of 10 estate sectors. This figure was similar to that obtained 10 years before in 1995, but the position of the rubber sector had dropped to second among estate crops, behind the palm oil sector.

In 1995, the value-added multiplier of the rubber crop sector was 0.015, ranking 52nd out of 66 Indonesian economic sectors, 9th out of 23 agriculture sectors, and 2nd out of 10 estate sectors. A multiplier value of 0.015 means that increasing the final demand by Rp 1 would increase value-added by Rp 0.015. This figure shows that the rubber sector played an important role in value-added. In 2005, the value-added multiplier of the rubber crop sector was 0.015, ranking 55th out of 66 Indonesian economic sectors, 12th out of 23 agriculture sectors, and 6th out of 10 estate sectors. These figures show that even though the value remained the same, the ranking of the rubber crop sector had dropped within the agricultural and estate sectors.

In 1995, the multiplier effect of the rubber crop sector for output, wages and salaries, and value-added was 1.358, 0.020, and 0.015, respectively. These values were low as proportions of the 66 Indonesian economic sectors, but relatively high within the agricultural and estate sectors. The value of the output multiplier was higher than those of the paddy sector and vegetable and fruit sector, but a little lower than that of the palm oil sector. The value of the multiplier of wages and salaries of the rubber crop sector was higher than those of the vegetable and fruit sector and the palm oil sector, but lower than that of the paddy sector. The value-added multiplier of the rubber crop sector was higher than that of the palm oil sector, but lower than those of the paddy sector and vegetable and fruit sector.

In 2005, the multiplier effect of the rubber crop for output, wages and salaries, and value-added was 1.392, 0.020, and 0.015, respectively. Therefore, the value of the output multiplier had increased since 1995, but the values of the multipliers of wages and salaries and value-added had remained relatively constant. This means that for the rubber crop, the output sector is responsive to final demand, but wages and salaries and value-added are not. In terms of the output multiplier, the same conditions are faced by the paddy sector, vegetable and fruit sector, and palm oil sector (Table 2.5c). The multipliers for wages and salaries and value-added had increased for the vegetable and fruit sector and palm oil sector, but decreased for the paddy sector.

2.7 Conclusion

This chapter explains the role of the rubber sector in Indonesian economic development in the decade from 1995 to 2005. Its role is explained in terms of (1) its contribution to gross output, wages and salaries, and value-added; (2) its backward and forward linkages; and (3) the multiplier effects of output, wages and salaries, and value-added. The data analyzed in this chapter were obtained from competitive import-type Indonesian input–output tables 1995 and 2005. The discussion focuses on comparing the rubber sector with other agricultural sectors such as the palm oil, paddy, and vegetable and fruit sectors.

In 1995, the rubber sector accounted for 0.38% of gross output, 0.97% of wages and salaries, and 0.50% of value-added. These are small proportions of the total economy, but larger than those of other agricultural sectors, especially other estate crop sectors. Within the agricultural sector, the rubber sector accounted for higher proportions of gross output, wages and salaries, and value-added than did the palm oil sector, but a lower proportion than did the paddy sector and vegetable and fruit sector. In 2005, the rubber sector accounted for 0.41%, 0.95%, and 0.57% of gross output, wages and salaries, and value-added, respectively. Therefore, within a decade, the share of gross output and value-added had increased, while the share of wages and salaries had decreased.

In 1995, the value of backward and forward linkages was 0.891 and 0.890, respectively. Because these values were less than 1, the rubber crop sector was categorized as an independent sector. That is, the rubber crop sector had low linkage to other sectors that either supply or demand. In terms of the forward linkage, the low value was because a share of the output was allocated to meet export demand without further processing. The same conditions were also faced by the vegetable and fruit sector and the palm oil sector. The paddy sector had forward linkage values higher than 1, indicating that it was strongly dependent on another sector; that is, as a raw material for the rice milling sector. In 2005, the value of the backward linkage of the rubber sector had decreased, indicating that the rubber crop sector was less able to attract other sectors as inputs. This might be because farmers were still cultivating rubber crops using traditional methods. Therefore, even though the rubber cultivation area had expanded, the farmers had not used appropriate production inputs. The value of the forward linkage of the rubber sector had increased over the decade, indicating that the rubber crop sector had become more able to push another sector (i.e., domestic rubber manufacturing).

In 1995, the multiplier effect of the rubber crop sector for output, wages and salaries, and value-added was 1.358, 0.02, and 0.015, respectively. These values were relatively low compared with those of other economic sectors, but higher than those of other parts of the agriculture sector, especially within the estate sectors. This means that increasing final demand for the rubber crop sector may increase output, wages and salaries, and value-added. In 2005, the multiplier effect was higher for output, but similar for wages and salaries and value-added.

The backward and forward linkage and multiplier effect analyses revealed that the rubber sector has a prominent role in the agricultural sector of the Indonesian economy. The rubber crop sector had low backward and forward linkage values, indicating that there is scope to improve this sector in terms of its relationships with other sectors. The backward linkage of the rubber crop sector can be increased by adding more production inputs to support the rubber crop sector.

Table 2.1 Proportion of gross domestic product by industry in 2000 at constant market price in 2000 and 2010.

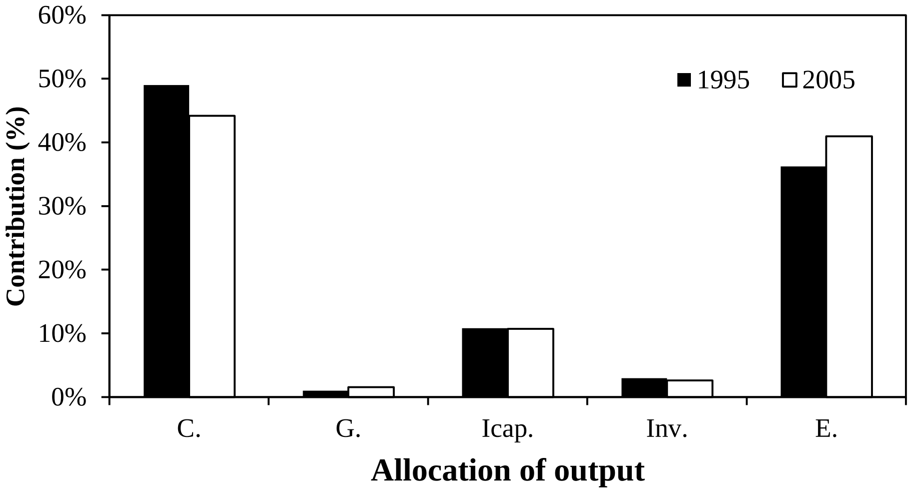
Sector	2000		2010	
Agriculture	216,832	(16)	304,777	(13)
Mining and quarrying	167,692	(12)	187,153	(8)
Manufacture	385,598	(28)	597,135	(26)
Electricity, gas and water supply	8,394	(1)	18,050	(1)
Construction	76,573	(6)	150,022	(6)
Trade, hotel, and restaurants	224,452	(16)	400,475	(17)
Transport and communication	65,012	(5)	217,980	(9)
Finance, real estate and service	115,463	(8)	221,024	(10)
Other services	129,754	(9)	217,842	(9)
Total	1,389,770	(100)	2,314,459	(100)

Source: Statistic Indonesia (2001-2011).
Notes: Values are thousand million Rupiahs.
Numbers in parentheses represent percentage of total in each column.

Table 2.2 Contribution of agricultural sector to gross output, income, and value-added components of Indonesian economy in 1995 and 2005.

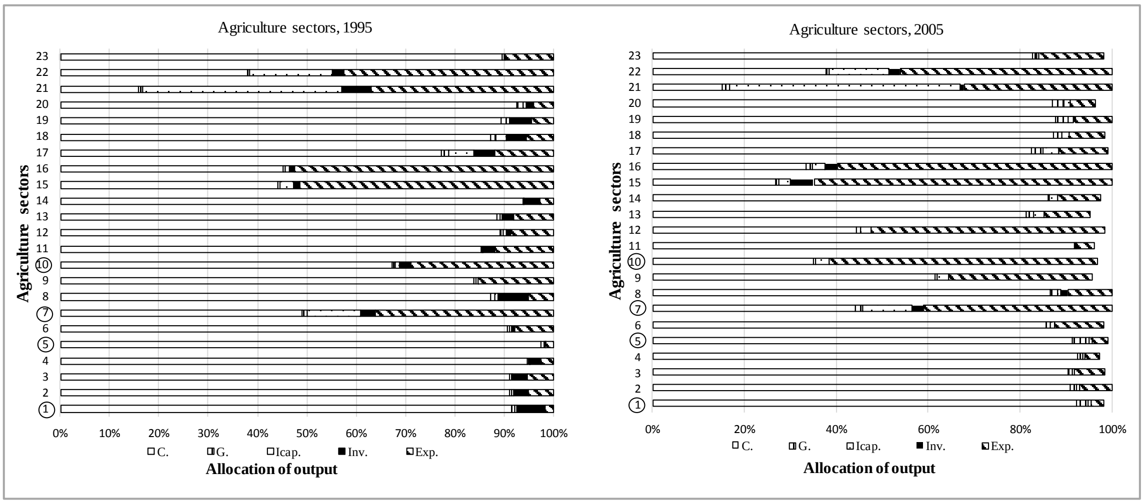
Sector	Code	Share of output[a]		Rankin agriculture				Share of wages and salaries[a]		Rank in agriculture				Share of value-added[a]		Rank in agriculture			
		1995	2005	1995		2005		1995	2005	1995		005		1995	2005	1995		2005	
Paddy	1	2.366	1.488	1		1		2.171	1.216	1		4		3.750	2.163	1		2	
Beans	2	0.370	0.179	11		13		0.226	0.143	15		17		0.584	0.286	9		13	
Maize	3	0.330	0.449	12		6		0.279	0.298	12		10		0.522	0.677	11		5	
Root crops	4	0.445	0.378	8		9		0.264	0.244	14		12		0.784	0.647	7		6	
Vegetable and fruit	5	1.621	1.462	2		2		1.285	1.552	2		1		2.754	2.520	2		1	
Other food crops	6	0.008	0.023	23		21		0.004	0.015	23		22		0.012	0.039	23		20	
Rubber	7	0.379	0.415	10	(2)	7	(1)	0.970	0.954	4	(1)	5	(1)	0.503	0.571	12	(2)	8	(1)
Sugarcane	8	0.381	0.117	9	(1)	17	(6)	0.626	0.182	7	(2)	13	(3)	0.565	0.165	10	(1)	17	(6)
Coconut	9	0.306	0.169	13	(3)	14	(4)	0.300	0.168	10	(3)	15	(5)	0.493	0.267	13	(3)	14	(4)
Oilpalm	10	0.280	0.346	14	(4)	11	(2)	0.298	0.439	11	(4)	8	(2)	0.387	0.432	14	(4)	11	(2)
Tobacco	11	0.124	0.037	18	(7)	20	(8)	0.208	0.048	16	(5)	19	(7)	0.127	0.036	19	(7)	21	(8)
Coffee	12	0.142	0.167	17	(6)	16	(5)	0.144	0.169	18	(7)	14	(4)	0.177	0.210	17	(6)	16	(5)
Tea	13	0.052	0.014	21	(9)	22	(9)	0.116	0.025	20	(8)	21	(9)	0.084	0.022	21	(9)	22	(9)
Clove	14	0.059	0.041	20	(8)	19	(7)	0.071	0.047	21	(9)	20	(8)	0.096	0.067	20	(8)	19	(7)
Fibercrops	15	0.020	0.006	22	(10)	23	(10)	0.031	0.004	22	(10)	23	(10)	0.032	0.010	22	(10)	23	(10)
Other estate crops	16	0.211	0.213	15	(5)	12	(3)	0.173	0.164	17	(6)	16	(6)	0.340	0.315	15	(5)	12	(3)
Other agriculture	17	0.163	0.169	16		15		0.267	0.262	13		11		0.242	0.259	16		15	
Livestock	18	0.566	0.376	7		10		0.611	0.469	8		7		0.741	0.568	8		9	
Slaughtering	19	1.265	0.689	3		5		0.866	0.525	5		6		0.818	0.562	6		10	
Poultry and its product	20	0.963	0.825	5		4		0.441	1.347	9		2		1.166	0.950	5		4	
Wood	21	0.903	0.383	6		8		0.788	0.429	6		9		1.344	0.628	4		7	
Other process products	22	0.095	0.093	19		18		0.118	0.112	19		18		0.151	0.155	18		18	
Fishery	23	1.197	1.279	4		3		1.041	1.317	3		3		1.792	2.068	3		3	

Source: Statistic Indonesia (1999, 2007).
Notes: [a]Values are percentage.
Numbers in parentheses represent rank in estate sector.



Source: Statistic Indonesia (1999, 2007).
Notes: C.: Private consumption expenditure; G.: Government expenditure; Icap.: Gross Capital Formation, Inv.: Change in Inventory; Exp.: Export.

Figure 2.1 Allocation output of rubber crop sector in 1995 and 2005.



Source: Statistic Indonesia (1999, 2007).

Notes:

C.: Private consumption expenditure; G.: Government expenditure; Icap.: Gross capital formation;

Inv.: Change in inventory; Exp.: Export.

Sector 1 – sector 6 = food, vegetable and fruit sector.

Sector 7 – sector 16 = estate sectors.

Sector 17 – sector 20 = livestock sectors.

Sector 21 – sector 22 = forestry sectors.

Sector 23 = fisheries sectors.

Sector 1= paddy sector.

Sector 5 = vegetable and fruit sector.

Sector 10 = palm oil sector.

Sector 7 = rubber crop sector.

Figure 2.2 Allocation of output of agriculture sectors in 1995 and 2005.

Table 2.3 Backward and forward linkages of agricultural sector in Indonesian economy in 1995 and 2005.

Sector	Code	Linkage index				Category[a]				Rank in agriculture							
		Backward		Forward		Backward		Forward		Backward				Forward			
		1995	2005	1995	2005	1995	2005	1995	2005	1995		2005		1995		2005	
Paddy	1	0.792	0.850	1.361	1.291	DD	DD	DD	DD	13		10		1		1	
Beans	2	0.784	0.773	0.791	0.752	In	In	In	In	18		18		10		14	
Maize	3	0.793	0.830	0.790	0.845	In	In	In	In	12		11		12		8	
Root crops	4	0.704	0.741	0.703	0.730	In	In	In	In	23		21		18		15	
Vegetable and fruit	5	0.737	0.737	0.736	0.806	In	In	In	In	22		22		16		11	
Other food crops	6	0.747	0.757	0.663	0.658	In	In	In	In	21		20		23		20	
Rubber	7	0.891	0.884	0.890	0.943	In	In	In	In	7	(4)	7	(5)	5	(2)	3	(2)
Sugarcane	8	0.844	0.887	1.063	1.120	DD	DD	DD	DD	8	(5)	6	(4)	2	(1)	2	(1)
Coconut	9	0.786	0.811	0.786	0.709	In	In	In	In	16	(7)	13	(7)	13	(5)	17	(6)
Oilpalm	10	0.894	0.953	0.886	0.853	In	In	In	In	6	(3)	4	(2)	6	(3)	7	(3)
Tobacco	11	1.097	1.032	0.705	0.656	DS	DS	DS	DS	2	(1)	3	(1)	17	(7)	21	(8)
Coffee	12	0.983	0.946	0.791	0.785	In	In	In	In	4	(2)	5	(3)	11	(4)	12	(5)
Tea	13	0.785	0.797	0.694	0.650	In	In	In	In	17	(8)	14	(8)	19	(8)	22	(9)
Clove	14	0.784	0.776	0.690	0.674	In	In	In	In	19	(9)	16	(9)	20	(9)	18	(7)
Fibercrops	15	0.777	0.725	0.672	0.640	In	In	In	In	20	(10)	23	(10)	22	(10)	23	(10)
Other estate crops	16	0.790	0.852	0.754	0.818	In	In	In	In	14	(6)	9	(6)	14	(6)	10	(4)
Other agriculture	17	0.826	0.823	0.837	0.861	In	In	In	In	10		12		8		6	
Livestock	18	0.962	0.877	0.974	0.930	In	In	In	In	5		8		3		4	
Slaughtering	19	1.256	1.169	0.738	0.711	DS	DS	DS	DS	1		1		15		16	
Poultry and its product	20	1.035	1.086	0.835	0.844	DS	DS	DS	DS	3		2		9		9	
Wood	21	0.814	0.771	0.969	0.782	In	In	In	In	11		19		4		13	
Other process products	22	0.790	0.775	0.680	0.666	In	In	In	In	15		17		21		19	
Fishery	23	0.826	0.794	0.863	0.899	In	In	In	In	9		15		7		5	

Source: Statistic Indonesia (1999, 2007).
Notes: [a] Category → In: independent, DD: dependently demanded, DS: dependently supplied.
Numbers in parentheses represent rank in estate sector.

Table 2.4 Multipliers of output, wage and salary, and value-added components of agricultural sector in Indonesian economy in 1995 and 2005.

Sector	Code	Multiplier of output		Rank in agriculture				Multiplier of income		Rank in agriculture				Multiplier of value-added		Rank in agriculture			
		1995	2005	1995		2005		1995	2005	1995		2005		1995	2005	1995		2005	
Paddy	1	1.207	1.339	13		10		0.026	0.019	1		6		0.042	0.030	1		3	
Beans	2	1.195	1.216	18		18		0.006	0.006	19		19		0.010	0.008	16		20	
Maize	3	1.209	1.306	12		11		0.007	0.009	17		17		0.010	0.014	15		14	
Root crops	4	1.072	1.167	23		21		0.004	0.005	23		21		0.009	0.010	17		18	
Vegetable and fruit	5	1.123	1.161	22		22		0.015	0.020	8		5		0.030	0.030	2		1	
Other food crops	6	1.139	1.192	21		20		0.004	0.005	22		22		0.005	0.006	23		22	
Rubber	7	1.358	1.392	7	(4)	7	(5)	0.020	0.018	3	(1)	7	(2)	0.015	0.015	9	(2)	12	(9)
Sugarcane	8	1.286	1.397	8	(5)	6	(4)	0.013	0.015	10	(3)	10	(4)	0.012	0.015	12	(5)	11	(6)
Coconut	9	1.197	1.276	16	(7)	13	(7)	0.009	0.012	14	(6)	13	(7)	0.011	0.013	13	(6)	15	(5)
Oilpalm	10	1.362	1.500	6	(3)	4	(2)	0.012	0.022	12	(5)	3	(1)	0.013	0.023	11	(4)	6	(7)
Tobacco	11	1.671	1.625	2	(1)	3	(1)	0.016	0.017	6	(2)	8	(3)	0.018	0.020	8	(1)	7	(10)
Coffee	12	1.497	1.490	4	(2)	5	(3)	0.012	0.014	11	(4)	11	(5)	0.013	0.016	10	(3)	9	(8)
Tea	13	1.196	1.254	17	(8)	14	(8)	0.007	0.008	18	(8)	18	(8)	0.006	0.009	20	(8)	19	(3)
Clove	14	1.195	1.222	19	(9)	16	(9)	0.005	0.006	21	(10)	20	(9)	0.005	0.007	22	(10)	21	(1)
Fibercrops	15	1.183	1.141	20	(10)	23	(10)	0.005	0.004	20	(9)	23	(10)	0.005	0.004	21	(9)	23	(2)
Other estate crops	16	1.204	1.342	14	(6)	9	(6)	0.008	0.013	16	(7)	12	(6)	0.009	0.015	18	(7)	10	(4)
Other agriculture	17	1.258	1.295	10		12		0.009	0.011	15		15		0.010	0.012	14		16	
Livestock	18	1.466	1.380	5		8		0.015	0.015	7		9		0.018	0.017	7		8	
Slaughtering	19	1.914	1.841	1		1		0.025	0.025	2		2		0.029	0.027	3		5	
Poultry and its product	20	1.577	1.710	3		2		0.017	0.031	4		1		0.026	0.029	4		4	
Wood	21	1.240	1.214	11		19		0.015	0.012	9		14		0.022	0.014	6		13	
Other process products	22	1.203	1.219	15		17		0.009	0.010	13		16		0.009	0.011	19		17	
Fishery	23	1.259	1.250	9		15		0.016	0.022	5		4		0.025	0.030	5		2	

Source: Statistic Indonesia (1999, 2007).
Note: Numbers in parentheses represent rank in estate sectors.

Table 2.5 Summary of share of Indonesian economy, backward and forward linkages, and multiplier effects of selected agricultural sectors in 1995 and 2005.

a. Share of rubber sector to gross output, income, and value-added.

Sector	Code	Share to gross output[a]			Share of wages and salaries[a]			Share of value-added[a]		
		1995	2005	Increasing/decreasing	1995	2005	Increasing/decreasing	1995	2005	Increasing/decreasing
Paddy	1	2.37	1.49	−0.88	2.17	1.22	−0.95	3.75	2.16	−1.59
Vegetable and fruit	5	1.62	1.46	−0.16	1.29	1.55	0.26	2.75	2.52	−0.23
Rubber	7	0.38	0.41	0.03	0.97	0.95	−0.02	0.5	0.57	0.07
Palm oil	10	0.28	0.35	0.07	0.3	0.44	0.14	0.39	0.43	0.04

b. Backward and forward linkages.

Sector	Code	Backward linkage			Forward linkage		
		1995	2005	Increasing/decreasing	1995	2005	Increasing/decreasing
Paddy	1	0.792	0.85	0.06	1.361	1.291	−0.07
Vegetable and fruit	5	0.737	0.737	0	0.736	0.806	0.07
Rubber	7	0.891	0.884	−0.01	0.89	0.943	0.05
Palm oil	10	0.894	0.953	0.06	0.886	0.853	−0.03

c. Multipliers of output, income, and value-added.

Sector	Code	Mult. of output			Mult. of wage and salary			Mult. of value-added		
		1995	2005	Increasing/decreasing	1995	2005	Increasing/decreasing	1995	2005	Increasing/decreasing
Paddy	1	1.207	1.339	0.132	0.03	0.02	−0.01	0.042	0.03	−0.01
Vegetable and fruit	5	1.123	1.161	0.038	0.01	0.02	0.01	0.03	0.03	0
Rubber	7	1.358	1.392	0.034	0.02	0.02	0	0.015	0.015	0
Palm oil	10	1.362	1.5	0.138	0.01	0.02	0.01	0.013	0.023	0.01

Source: Tables 2.2, 2.3, and 2.4.
Notes: [a]Values are percentage. − : decreasing.

Chapter 3
General Figures and Income of Rubber Farmers in Indonesia

3.1 Introduction

This chapter describes the general conditions of rubber farmers in Indonesia, including their demographic conditions, and their income. The general conditions of rubber farmers are explained on a national level and for the major islands: Java, Sumatra, Bali and Nusa Tenggara, Kalimantan, and Sulawesi and East Indonesia. The incomes are compared among rubber farmers and farmers of other estate crops (palm oil) and food crops (paddy and maize). The aim of these comparisons is to assess the performance of the rubber crop relative to that of other crops in Indonesia.

3.2 Data

Farmer income data and household consumption data were analyzed to explain the general conditions of rubber farmers in Indonesia. The farmer income data were obtained from the Survei Pendapatan Petani 2004 (SPP-2004: Statistic Indonesia, 2004b). These are the most recent data available, because this survey is conducted only every 10 years. The household consumption data were obtained from the Survei Sosial Ekonomi Nasional (SUSENAS-2005: Statistic Indonesia, 2005b).

The SPP-2004 data represent the results of a household farm income survey across the whole agricultural sector, including food crops, estate crops, horticultural crops, fisheries, and livestock. This survey included 316,669 samples, where each sample was a farmer household engaged in agriculture. It is possible that one farmer can farm more than one crop. This survey focuses on farmer income and wealth; therefore, production inputs refer to production costs, instead of physical inputs (e.g., area, seed, amount of fertilizers, and number of labor hours). However, data related to farmer wealth such land holding (agricultural and non-agricultural land) are available.

The SUSENAS-2005 data represent the results of a household survey related to education, health, and housing, and include data related to society, culture, and consumption. The survey included 62,029 samples. This survey explained household expenditure in terms of food and non-food expenditure, and rural and urban level.

3.3 Demographic Conditions of Rubber Farmers in Indonesia

Smallholder rubber farmers are concentrated in Sumatra and Kalimantan Island. In total, there are 24,640 rubber farmers (samples), 65% of whom are located in Sumatra Island, 33% in Kalimantan Island, and the remainder in Java, Bali and Nusa Tenggara, and Sulawesi and East Indonesia. Details of the demographic conditions of rubber farmers are shown in Table 3.1.

The average age of rubber farmers is 44, the youngest is 20 and the oldest is 99. There is a low literacy rate among the heads of households. More than 70% of the heads of households had no schooling or only elementary schooling, and only 11.3% went to a senior high school or university. This low level of education may affect the rate of adopting new technology. The average number of family members in rubber farmer families is 4.4 persons. This may affect how much family labor is available for farming the rubber crop.

The average agricultural land holding of rubber farmers is 2.32 ha, with 2.1 ha farmland and 0.2 ha wetland. Rubber crops cannot grow in wetland areas; therefore, the proportion of farmland is higher than that of wetland. The wetland area is used to grow seasonal crops such as paddy. Rubber farmers also have some non-agricultural land that is used for housing. The area of non-agricultural land is smaller in Java than outside of Java, because the population density is higher in the former. Rubber farmers in Java farm five crops, while those in Sumatra farm two. This may affect their income source.

The per-capita land holding of rubber farmers is 0.52 ha, higher than that of paddy and maize farmers (0.23 ha and 0.20 ha, respectively), but lower than that of palm oil farmers (0.60 ha). Rubber farmers and palm oil farmers account for the largest share of landholdings in Sumatra and Kalimantan Island, but paddy farmers and maize farmers account for the major share of landholdings across all islands (Table 3.2). Although paddy farmers have the largest share of agricultural landholdings across all islands, the per-capita agricultural land holding is smaller in Java than in other areas, because the average family is bigger in Java than elsewhere.

3.4 Income of Rubber Farmers in Indonesia

The sources of farmer income in Indonesia are agriculture, non-agriculture, remittance and transfer. A person may work as an employee in the agricultural sector or in a non-agricultural sector. These descriptions are shown in Table 3.3. Generally, agriculture is the main income source for farmers in Indonesia. Agriculture accounts for 37% of farmer income in Java and 64% in Kalimantan. In Java, the proportion of income from the non-agricultural sector is relatively high, 18% and 19% as owner and employee, respectively. These figures differ for the other islands, and the proportions of income from the non-agricultural sector are smaller in Sumatra and Kalimantan.

Generally, among the agricultural sector, wetland paddy is the largest contributor to farmer income in Indonesia (Table 3.4). Paddy contributes 18% of total farmer income, followed by fisheries and then rubber, which contributes 12% of total farmer income. Together, the palm oil, cocoa, coconut, coffee, and rubber sectors contribute 31% of total farmer income in Indonesia. This means that farmer income in Indonesia relies heavily on estate crops.

Each crop has a dominant role in some part of Indonesia. For example, the wetland paddy crop is dominant in Java, contributing 32% of farmer income. The rubber crop is dominant in Sumatra and Kalimantan Island. The fishery sector is dominant in Kalimantan, Sulawesi, and East Indonesia Island. The type of crop that dominates in each area is related to the land characteristics and climate. The crops are also supported by government initiatives to provide agricultural infrastructure such as irrigation and roads.

Sumatra is a tropical rainforest area, and most of the farmers' income is derived from estate crops. Rubber and palm oil crops provide 26% and 16% of farmers' income, respectively. The climate of Sumatra is well suited to cultivation of rubber and palm oil crops. The paddy crop in Sumatra is dominated by wetland paddy. In Bali and Nusa Tenggara, the paddy crop is the main source of farmers' incomes.

Rubber farming contributes 49% of the total income of rubber farmers on average (Table 3.5), and 51% and 45% of farmers' incomes in Sumatra and Kalimantan Island, respectively. In these regions, the paddy crop contributes 3% of total income. Some rubber farmers have wetland to grow paddy, rather than non-wetland to grow estate crops.

The cost structure is a very important part of rubber farming. Analyzing the cost structure can explain how this type of farming is conducted, and can allow comparisons between rubber farming and farming of other estate crops such as palm oil, coconut, coffee, and cocoa, and other seasonal crops such as paddy and maize. This cost structure over a year, in average values, is shown in Table 3.6.

The average income per rubber farmer household is Rp 6.8 million a year (Table 3.6). This value is three times higher than the income from paddy crops, ten times higher than the income from maize crops, but less than the income from palm oil crops. Therefore, rubber farms generate more income than do farms cultivating other crops, except for those producing palm oil. However, because the data set is incomplete, the farm income per land area cannot be calculated.

The cost structure of the farm is described over the course of a year, and is compared with revenue. The percentages show how much of the revenue is required to fulfill the farm costs. The total cost per revenue is shown in Table 3.6 (column 10). The total cost per revenue for rubber crops is 18.51%; that is, 18.51% of the revenue is used to meet the production costs. Comparing rubber with other crops, the total cost per revenue is lower for rubber than for palm oil, coconut, coffee, and other seasonal crops. The income per revenue of the rubber crop is 81.25%; that is, 81.25% of the revenue generates income. This income includes family labor. This percentage is higher than those for palm oil, paddy, and maize crops. Regardless of farm size, the income per revenue is higher for rubber than for those crops.

The seeding cost per revenue is only 1.11%, similar to that of other estate crops, but smaller than that of seasonal crops. This is because the seeding cost for estate crops is calculated as expenses for partial replanting each year, while that for seasonal crops is calculated as an annual expense. This is because estate crops are perennial crops with a long economic life.

The fertilizer cost per revenue for rubber crops is only 1.8%, lower than those for palm oil, coffee, cocoa, and other seasonal crops. However, rubber farmers only apply small amounts of fertilizer to their plots, as discussed later.

The labor cost is the main expense for all crops. For estate crops, most of the labor cost is for harvesting. For the rubber crop, for instance, trees can be tapped every day after they reach the tapping stage (4–6 years). Palm trees take 3 years to reach the harvest stage, after which palm oil is harvested twice a month all year. Coconuts are harvested from coconut trees year round after the trees reach 5–6 years of age. However, most of this labor is hired labor.

3.5 Per-capita Income of Rubber Farmers

As explained in the previous sub-chapter, the main income of rubber farmers is from rubber (49% of total income). The income per household is higher for rubber farmers than for paddy and maize farmers, but lower than for palm oil farmers. However, it is unclear how the farmer income per capita compares between rubber farmers and farmers of other crops. The aim of this sub-chapter is to explain this issue in detail.

The per-capita income of rubber farmers is Rp 3.1 million, which is higher than that of paddy and maize farmers but lower than that of palm oil farmers (Table 3.7). The per-capita income of rubber farmers in Sumatra is Rp 3.3 million, the highest among all the Indonesian islands. In Sumatra and Kalimantan Island, where estate crops such rubber and palm oil are concentrated, the per-capita income is lower for rubber farmers than for palm farmers. In Java, where paddy and maize crops are concentrated, the per-capita income is slightly higher for rubber farmers than for paddy and maize farmers.

3.6 Per-capita Consumption

Household consumption describes household expenses that are required to meet the needs of daily life. The data were obtained from the National Survey of Social Economics (2005). In that survey, the households were divided into rural and urban areas. An urban area is defined based on population density, percentage of farm households, and access to urban facilities such as educational and health care facilities, markets, and communication. Based on this definition, some rubber farmers can be categorized as rural and some as urban. The per-capita income is derived from household income divided by the number of family members.

Generally, the per-capita consumption in rural areas is Rp 2.4 million/year, half of that in urban areas (Rp 4.9 million) (Table 3.8). This may be because living standards are generally lower in rural than in urban areas. The per-capita food consumption in rural areas is Rp 1.5 million, slightly lower than that in urban areas (Rp 2.2 million), while per-capita non-food consumption in rural areas (Rp 0.9 million) is one-third that in urban areas (Rp 2.7 million).

3.7 Conclusion

This chapter explains the general conditions of rubber farmers in Indonesia, including their demographic and income conditions. The data were collected in the Survei Pendapatan Petani 2004 (Statistic Indonesia, 2004) and the Survei Sosial Ekonomi Nasional 2005 (Statistic Indonesia, 2005).

Most of the income for farmers in Indonesia is from paddy, fish, rubber, and palm oil. The top five estate crops are rubber, palm oil, cocoa, coconut, and coffee, which together account for 31% of farmers' income in Indonesia. For rubber farmers, the main source of income is from rubber farming (49%), while the rest is from other crops and other sectors—for example, when farmers are employed in other agricultural and non-agricultural jobs.

The average landholding of rubber farmers is 2.3 ha, or 0.52 ha on a per-capita basis. This is higher than those of paddy and maize farmers (0.23 ha and 0.2ha, respectively) but lower than that of palm oil farmers (0.6 ha). The per-capita income of rubber farmers is Rp 3.1 million, higher than those of paddy and maize farmers (Rp 2.1 and 1.8 million, respectively), but lower than that of palm oil farmers (Rp 4.3 million).

Rubber is a family-labor-intensive crop. The total cost of cultivation is 18.51% of income, covering seed cost (1.11%), labor cost (12.55%), land rent cost (1.06%), fertilizer and pesticide costs (1.8%) and other costs (2.01%), while 81.25% is left as income for the farmers' families, and includes the family labor cost. This value of 18.51% is lower than the corresponding values for the paddy crop, maize crop, and palm oil crop (37.4%, 38.1%, and 26.1%, respectively).

The per-capita consumption of households in rural and urban areas are Rp 2.4 million and Rp 4.9 million, respectively. In rural areas, 62% of consumption is for food and 38% for non-food items. In urban areas, 45% of consumption is for food and 55% is for non-food items.

Table 3.1 Demographic conditions of rubber farmers in Indonesia in 2004.

Level	Java	Sumatra	Bali and Nusa Tenggara	Kalimantan	Sulawesi and East Indonesia	Indonesia
N	226	16,065	14	8,283	52	24,640
Age						
- Average[a]	44.7	45.5	52.5	43.9	43.7	44.5
- ≤ 44 years[b]	50	52	42.9	54.4	48.1	52.8
- > 44 years[b]	50	80	57.1	45.6	51.9	47.2
Gender						
- Male[b]	95.6	91.7	85.7	92.5	92.3	92
- Female[b]	4.4	8.3	14.3	7.5	7.5	8
Education						
- No schooling[b]	38.5	26.7	50	32.4	32.7	28.8
- Elementary school[b]	54.4	45.1	42.9	39.7	53.8	43.4
- Junior high school[b]	2.7	17.1	0	16.1	7.7	16.6
- Senior high school and higher[b]	4.4	11.1	7.1	11.9	5.8	11.3
Family members						
- Average number of people	4.37	4.43	4	4.35	5.35	4.4
- ≤ 4 people[b]	57.1	56.6	57.1	58.8	38.5	57.3
- > 4 people[b]	42.9	43.4	42.9	41.2	61.5	42.7
Land holding (average)						
- Agricultural land						
- Wetland[c]	3,146	1,432	1,275	3,357	558	2,092
- Not wetland[c]	8,938	20,229	9,784	23,183	14,756	21,101
- Non-agricultural land[c]	247	1,002	649	1,328	682	1,104
- Total land occupation[c]	12,301	22,657	11,709	27,892	15,996	24,301
Number of crops						
- Number of crops	5.05	2.41	6.71	3.21	4.44	2.7

Source: Statistic Indonesia (2004b).
Note: [a]Values in year. [b]Values in percentage. [c]Value in m^2.

Table 3.2 Per capita agricultural landholding of farmers based on main crop type.

Main crop type	Java	Sumatra	Bali and Nusa Tenggara	Kalimantan	Sulawesi and East Indonesia	Indonesia
Rubber						
Number of families	226	16,066	14	8,282	52	24,640
Total number of people	988	71,221	56	36,024	278	108,567
Total agriculture land holding[a]	2.7×10^6	3.48×10^8	1.5×10^5	2.19×10^8	7.9×10^5	5.71×10^8
Per-capita agriculture land holding[a]	2,764	4,866	2,765	6,101	2,864	5,264
Palm oil						
Number of families	72	6,821	41	819	285	8,038
Total number of people	300	29,903	174	3.403	1,161	34,941
Total agriculture land holding[a]	8.1×10^5	1.76×10^8	3.53×10^5	2.64×10^7	6.4×10^6	2.10×10^8
Per-capita agriculture land holding[a]	2,711	5,904	2,032	7,773	5,524	6,026
Paddy						
Number of families	84,216	35,892	10,552	23,365	26,382	180,407
Total number of people	324,021	157,063	50,642	99,639	114,616	745,981
Total agriculture land holding[a]	4.03×10^8	4.67×10^8	1.12×10^8	4.87×10^8	3.02×10^8	3.02×10^8
Per-capita agriculture land holding[a]	1,244	2,973	2.225	4,888	2,635	2,375
Maize						
Number of families	38,574	6,112	12,288	3,899	13,596	74,469
Total number of people	148,266	26,694	56,711	17,086	58,500	307,257
Total agriculture land holding[a]	1.83×10^8	7.2×10^7	1.3×10^8	9.0×10^7	1.55×10^8	6.33×10^8
Per-capita agriculture land holding[a]	1,240	2,730	2,302	5,320	2,656	2,062

Source: Statistic Indonesia (2004b).
Note: [a]Value are m^2

Table 3.3 Source of farmer income in Indonesia by major island in 2004.

Province	Java	Sumatra	Bali and Nusa Tenggara	Kalimantan	Sulawesi and East Indonesia	Indonesia
N	128,640	75,102	26,690	32,289	53,948	316,669
Agriculture	361,990	492,300	105,900	206,100	320,100	1,490,000
	(37)	(56)	(47)	(64)	(61)	(50)
Non- agriculture	181,000	98,430	28,620	53,340	62,340	424,000
	(18)	(11)	(13)	(17)	(12)	(14)
Remittance and transfer	172,374	102,508	39,808	48,440	71,983	435,100
	(17)	(12)	(18)	(15)	(14)	(15)
Agriculture employee	84,274	80,260	8,820	21,560	23,245	218,000
	(9)	(9)	(4)	(7)	(4)	(7)
Non- agriculture employee	191,640	101,400	42,790	44,040	49,470	429,000
	(19)	(12)	(19)	(14)	(9)	(14)
Total	991,245	873,930	225,900	322,710	527,260	2,992,000
	(100)	(100)	(100)	(100)	(100)	(100)

Source: Statistic Indonesia (2004b).
Notes: Values are thousand million Rupiahs.
Numbers in parentheses represent percentage of total in each column.
Exchange rate of 1US$=Rp 12,135, October 2014.

Table 3.4 Source of farmer income from agriculture in Indonesia by major island in 2004.

Level		Java	Sumatra	Bali and Nusa Tenggara	Kalimantan	Sulawesi and east Indonesia	Indonesia
N		127,041	73,532	27,288	30,910	53,286	312,057
Paddy wetland		111,247	63,431	17,414	25,063	41,246	258,401
		(32)	(13)	(16)	(14)	(14)	(18)
Fisheries		35,193	44,552	7,338	35,587	54,328	176,998
		(10)	(9)	(7)	(19)	(18)	(12)
Rubber		510	122,931	9	46,060	213	169,723
		(0)	(26)	(0)	(25)	(0)	(12)
Palm oil		139	76,004	20	4,411	2,567	83,142
		(0)	(13)	(0)	(2)	(1)	(6)
Cocoa		146	4,596	2,711	1,530	64,964	73,947
		(0)	(1)	(3)	(1)	(21)	(5)
Coconut		7,634	27,312	3,909	5,228	21,773	65,855
		(2)	(6)	(4)	(3)	(7)	(5)
Cow-livestock		22,743	7,177	11,307	3,884	7,108	52,219
		(6)	(2)	(11)	(2)	(2)	(4)
Maize		19,364	9,797	7,866	3,230	11,708	51,965
		(6)	(2)	(7)	(2)	(4)	(4)
Coffee		3,157	29,929	4,013	951	3,044	41,095
		(1)	(6)	(4)	(1)	(1)	(3)
Paddy upland		4,026	7,195	3,612	19,384	2,576	36,793
		(1)	(2)	(3)	(11)	(1)	(3)
Others		147,064	85,279	48,422	38,706	95,927	415,351
		(42)	(18)	(45)	(21)	(31)	(29)
Total		351,224	478,203	106,621	184,033	305,455	1,425,489
		(100)	(100)	(100)	(100)	(100)	(100)

Source: Statistic Indonesia (2004b).
Notes: Values are million rupiahs.
Numbers in parentheses represent percentage of total in each column.

Table 3.5 Average income of rubber farmers by source and major island in Indonesia in 2004.

Level	Java	Sumatera	Bali and Nusa Tenggara	Kalimantan	Sulawesi and East Indonesia	Indonesia
N	226	16065	14	8283	52	24640
Rubber	2,259	7,636	655	5,567	4,092	6,879
	(25)	(51)	(11)	(45)	(41)	(49)
Paddy	1,364	424	352	421	150	431
	(15)	(3)	(6)	(3)	(2)	(3)
Fisheries	237	176	0	109	209	154
	(3)	(1)	(0)	(1)	(2)	(1)
Palm oil	0	448	0	88	0	322
	(0)	(3)	(0)	(1)	(0)	(2)
Other agriculture	1,694	1,176	2,874	1,729	2,163	1,370
	(18)	(8)	(50)	(14)	(22)	(10)
Agriculture service	148	132	29	61	52	108
	(2)	(1)	(1)	(0)	(1)	(1)
Non-agriculture	773	1,016	118	1,225	676	1,083
	(8)	(7)	(2)	(10)	(7)	(8)
Other income and transfer	1,532	1,652	1,182	1,542	978	1,612
	(17)	(11)	(21)	(12)	(10)	(12)
Agriculture's employee	575	1,079	189	517	291	883
	(6)	(7)	(3)	(4)	(3)	(6)
Non-agriculture's employee	596	1,056	268	977	906	1,024
	(6)	(7)	(5)	(8)	(9)	(7)
Total income	9,182	14,844	5,705	12,469	10,006	13,978
	(100)	(100)	(100)	(100)	(100)	(100)

Source: Statistic Indonesia (2004b).
Notes: Values are thousand Rupiahs.
Numbers in parentheses represent percentage of total in each column.

Table 3.6 Average production cost, revenue, and income of estate crops and seasonal crops in 2004.

Crop	N	Number of trees or area[a]	Revenue	Seeding cost	Fertilizer, pesticide cost	Labor cost	Land rent cost	Other costs	Total cost	Income
Rubber	24,640	2,114	8,442	93	152	1,059	89	170	1,563	6,859
			(100.0)	(1.1)	(1.8)	(12.5)	(1.1)	(2.0)	(18.5)	(81.2)
Palm oil	8,097	1,951	13,956	198	1,544	1,420	136	346	3,643	10,263
			(100.0)	(1.4)	(11.1)	(10.2)	(1.0)	(2.5)	(26.1)	(73.5)
Paddy	180,407	6,185	2,604	81	284	431	88	115	974	1,629
			(100.0)	(3.1)	(10.9)	(16.6)	(3.4)	(4.4)	(37.4)	(62.6)
Maize	74,469	4,229	1,119	65	127	169	27	36	426	693
			(100.0)	(5.8)	(11.3)	(15.1)	(2.4)	(3.2)	(38.1)	(61.9)

Source: Statistic Indonesia (2004b).
Notes: Values are thousand Rupiahs.
Numbers in parentheses represent percentage of revenue.
[a]Rubber, palm oil, coconut, coffee crops are measured by number of trees, while paddy and maize crops are measured by m^2.

Table 3.7 Per capita income of crop farmers in Indonesia in 2004.

Crop	Java	Sumatra	Bali and Nusa Tenggara	Kalimantan	Sulawesi and East Indonesia	Indonesia
Rubber						
N	226	16,066	14	8,282	52	24,640
Per-capita income[a]	2,100	3,349	1,426	2,865	3,172	3,172
Palm oil						
N	72	6,821	41	819	285	8,038
Per-capita income[a]	2.635	4,468	1,836	3,285	3,803	4,302
Paddy						
N	84,216	35,892	10,552	23,365	26,382	180,407
Per-capita income[a]	1,955	2,188	1,874	2,420	1,954	2,061
Maize						
N	38,574	6,112	12,288	3,899	13,596	74,469
Per-capita income[a]	1,739	2,187	1,497	2,821	2,014	1,846

Source: Statistic Indonesia (2004b).
Note: [a]Values are thousand Rupiahs.

Table 3.8 Per capita consumption by area and major island in 2004.

Level	Area	Java	Sumatra	Bali and Nusa Tenggara	Kalimantan	Sulawesi and East Indonesia	Indonesia
N	Urban	10,697	3,961	1,173	1,991	7,503	25,325
	Rural	13,760	8,552	2,282	3,648	8,462	36,704
Total number of people	Urban	41,955	17,513	4,778	8,320	29,567	102,133
	Rural	51,353	35,973	10,280	15,021	34,782	147,409
Per capita consumption[a]	Urban	4,193	4,863	5,368	4,919	5,960	4,933
	Rural	2,736	2,313	2,276	2,681	2,273	2,442
Per capita food-consumption[a]	Urban	1,938	2,313	2,264	2,480	2,467	2,215
	Rural	1,350	1,768	1,324	1,798	1,398	1,507
Per capita non-food consumption[a]	Urban	2,255	2,550	3,105	2,440	3,493	2,719
	Rural	964	968	952	884	875	935

Source: Statistic Indonesia (2005b).
Note: [a]Values are thousand Rupiahs.

Chapter 4

Role of Improved Technology in Increasing Productivity and Income of Smallholder Rubber Farms in Indonesia: A Case Study

4.1 Introduction

Indonesia has the largest area of rubber plantations in the world, 2.7 million ha in 2008, or 41% of the total rubber plantation area worldwide (Association of Natural Rubber Producing Countries, 2010). More than 65% of the global rubber plantation area is in Indonesia, Thailand, and Malaysia. However, Indonesia's rubber productivity is 993 kg/ha, lower than those of Thailand and Malaysia, which are 1,699 kg/ha and 1,411 kg/ha, respectively (Association of Natural Rubber Producing Countries, 2010). This low productivity prevents Indonesia from being the largest rubber producer in the world.

Rubber plays an important role in the Indonesian economy. The rubber sector accounts for 5% of total exports (increased from 1% in 2000), the second highest contribution among the main estate crops[1]. Therefore, the rubber sector plays an important role in earning international currency. This sector includes two related sectors, the rubber crop sector and the rubber manufacturing sector, which processes raw rubber materials into further products such as TSR, RSS, and others. The rubber crop is the main income source for at least 2.2 million farmers (Directorate General of Estate Crops-Minister of Agriculture, 2013). Based on the assumption that each family has four members, approximately eight million people in Indonesia rely on this crop.

Rubber is a specific and perennial crop. It requires particular climatic conditions: tropical temperatures (20–34°C), high humidity and precipitation (100 rainy days per year), and it cannot tolerate strong winds. The crop takes 4–8 years to reach the tapping stage (the "gestation" period), and then is capable of producing latex for at least 25 years.

[1] Main estate crops are palm oil, rubber, coconut, coffee, and cocoa.

There are three types of rubber plantations in Indonesia: smallholder rubber farms, government plantations, and private plantations (estates)[2]. Smallholder rubber farms account for 80% of total production and 85% of the total rubber cultivation area, whereas government plantations and private plantation account for 9% and 11% of total production, and 7% and 8% of the total rubber plantation area, respectively. The productivity of small smallholder rubber farms (1,036 kg/ha/year) is lower than that of government plantations (1,509 kg/ha/year) and private plantations (1,553 kg/ha/year) (Statistic Indonesia, 2011b). Although the productivity of smallholder farms is low, it has gradually increased from 617 kg/ha/year in 2002 to 1,036 kg/ha/year in 2011, corresponding to an increase in 419 kg/ha/year over a decade. This increase in productivity raises the question as to which factors were responsible for the improvement.

Some studies have focused on this issue. Barlow and Tomich (1991, p. 34) reported that the yield of smallholder rubber farms in 1986 was 525 kg/ha, lower than that from plantations (1,186 kg/ha[3]). This was because private companies (plantations) cultivated improved rubber varieties in a monoculture system and used good management practices, whereas smallholder farmers cultivated old (unimproved) varieties, their trees were poorly developed and weak, and they did not apply fertilizer or control weeds (Barlow and Tomich, 1991, p. 36). Gouyon et al. (1993, p. 182) described the smallholder rubber farms as a rubber jungle system. Smallholder farmers grew rubber in this way because (1) farm land was abundant and suitable for swidden farming; (2) few labor or material inputs were required; and (3) this system maintained species biodiversity in forested areas. Briefly, the rubber jungle system consists of rubber cultivated alongside secondary crops, as opposed to the monoculture system used on plantations. The secondary crops are seasonal crops such as timber and fruit crops.

Penot and Wibawa (1996) explained the history of the shift from the rubber jungle system to the rubber agroforestry system (RAS), even though most farmers still relied on

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[2] Smallholder rubber farms are those managed by household farmers and family labor, whereas government and private plantations are farms managed by the government and private companies with hired labor (Hayami, 2002, 2010).

[3] Data source: Statistic Indonesia (1981–89), Direktorat Jenderal Perkebunan (Directorate General of Estates Crop, 1989).

unselected seedlings for cultivation in the rubber jungle system in 2002 (Penot, 2004). The shift can be summarized as follows: (1) first, there was a shift from the swidden cultivation system to the rubber jungle system; (2) then, the rubber jungle system shifted to the rubber agroforestry system. Before the rubber tree was introduced in the 19th century, most of the forested areas were being converted into upland paddies to grow main crops. Farmers cultivated rice together with other crops such as timber and fruit. After the rubber tree was introduced, farmers began cultivating rubber crops using indigenous methods; that is, in the same way they cultivated upland paddy fields. This was known as the rubber jungle system. In this system, the farmers grew unselected seeds[4] that were collected from the first rubber trees growing in larger plantations, and they did not apply fertilizers or control weeds. The yield from these seedlings was sufficient to generate income at that time. However, as population increased, agricultural land became scarcer and farmers were forced to improve production from smaller blocks of land. The farmers began to plant new materials (selected seeds and clones), applied fertilizers and pesticides, controlled weeds, and grew rubber trees together with a secondary crop. The system is known as the rubber agroforestry system (RAS system). The shift from the rubber jungle to the RAS system increased production.

The shift from cultivation of upland rice to planting trees (such as rubber) rose as a response to population pressure. This shift was supported by improved infrastructure and roads (Angelsen, 1994). It is expected that this shift in land use will promote individualization of land tenure in customary land areas (Otsuka et al., 1997; Otsuka et al., 2001), and change the forest landscape (Suyanto and Otsuka, 2001; Jong, 2001).

Previous studies have described how using high-yielding varieties and agricultural management practices improve rubber productivity. Improved technologies, in terms of planting materials (Joshi et al., 2003; Wibawa et al., 2005) and cultivation practices, have increased rubber production (Barlow and Jayasurya, 1984). However, previous studies

[4] Unselected seedlings are those grown from ordinary unimproved seed. Selected seedlings are those grown from seed collected beneath trees in special seed gardens. Trees grown from selected seedlings produce substantially higher yields than those from ordinary stock. Budgrafts are plants produced by grafting improved material onto young seedling stock (Barlow and Muharminto, 1982). Rubber clones have been selected at Research Stations. Multiplication of clonal planting material through grafting requires, as a minimum, a budwood garden, a rootstock nursery, and skill in grafting techniques (Penot, 2004).

have not explained in detail how smallholder farmers run their rubber farms and how they adopt new and improved technologies.

Chapter 4 aims to explore the role of improved technology in smallholding rubber farms in Indonesia, and to identify ways to improve the uptake of new technology. In this context, improved technology covers the cultivation of HYV, fertilizer, pesticide, and stimulant applications, and controlling grass weeds. The detailed objectives are (1) to compare outputs between rubber farmers using improved technology and those who do not, (2) to identify the ways in which farmers adopt the improved technology, and (3) to identify the constraints to using improved technology.

4.2 Research Area and Selected Farmers

Smallholder rubber farms are concentrated in Sumatra and Kalimantan Island. This research was conducted in Pelajau Ilir Village, Banyuasin III Sub District, Banyuasin District, South Sumatra Province, one of the rubber centers in Indonesia. The research area is located 64 km west of Palembang, the provincial city of South Sumatra. This site was selected because some of the farmers are using improved technology to cultivate rubber trees and some are not.

To address the objectives of this chapter, three farmers were selected for detailed interviews and data collection. One farmer used improved technology. One farmer did not use improved technology and had a plot of young rubber trees. The other farmer did not use improved technology and had a plot of old rubber trees. Comparisons among these plots were intended to show differences in production between farms with improved technology and those without, and between young and old rubber trees.

The data were collected through daily farm records for 1 year, from June 2013 to May 2014. The daily record data included (1) precise weekly rubber production and its trends over the year, (2) production inputs such as amounts of fertilizer, pesticide, and stimulant used, and timing of their application, and (3) weekly tapping labor hours. The daily records were confirmed, and the farmers were interviewed in-depth about their farming practices.

Each farm was plotted using the Geographical Positioning System (GPS). This mapping process had two main advantages: (1) it revealed other conditions such as crop density, and bush and tree condition; and (2) it showed the distance of each plot from the village road, and showed road access to selected plots. The mapping process also allowed a firm measurement of the daily record of yield/area.

The yield from each plot is expressed as yield/area, yield/tree, and yield/labor hour. The production inputs and costs for the plots are also shown. By calculating productivity, we could identify which plot had the highest productivity and efficiency.

Rubber trees were first introduced into Indonesia by the Dutch in 1876. The first rubber crops were grown in an plantation system. Since then, the rubber plantation area has increased rapidly to meet the growing global demand. After Indonesian independence in 1945, the government occupied and managed 75% of the abandoned rubber area, converting it into government plantations (Booth, 1988, p. 208). Plantations are managed by private companies, who rent land either from the government or from smallholders. Smallholder rubber farms are located in tropical forest areas that were abundant in the past but have become scarcer over recent years because of the increasing population (Penot, 2004).

The climate at Pelajau Ilir is very humid, with a temperature range of 25–34°C, and very light winds (1–3 m/s). The village is located in a forest area, 28 m above sea level. The conditions at Pelajau Ilir are well suited to rubber cultivation. Almost 90% of households in the village are engaged in rubber tree cultivation. Therefore, rubber farming is the most important source of household income (Table 4.1).

Rubber is a perennial crop that grows in tropical forest areas. Rubber trees remain productive for at least 25 years. However, to obtain the highest yield, the farmer must maintain the crop by applying fertilizer and pesticide and by controlling grass weeds. Generally, the farmer begins to tap rubber trees in the early morning (5.30 am), three times a week, throughout the whole year. The farmer sells the rubber product as slab rubber via a farmers' organization or a middleman once a week. The farmers' organizations decide the price by an auction. The traders bid in the auction considering the reference price set by the rubber factory.

In this research, the outputs of farmers using improved technology were compared with those of farmers who do not. Improved technology was applied in plot A by Farmer A;

un-improved technology with young trees was applied in plot B by Farmer B; and un-improved technology with old trees was applied in plot C by Farmer C. Details of the plots are shown in Figure 4.1. As shown in the map, plot A was close to the village road, while plots B and C were located in the middle of the jungle with poor road access. Plot B consisted of two plots, but they were analyzed as one plot because the farmer produced slab rubber from both plots.

Table 4.2 shows the demographic conditions of the three selected farmers. All farmers had more than one plot and most of the plots were planted with rubber trees. All farmers were categorized as smallholder farmer because their land holdings were relatively small (a few hectares) and family labor was used (Hayami, 2002). All of the farmers received some plots from their parents when they got married, and most of the plots were already established with rubber trees. After working their plots for several years, the farmers were able to buy their own land for rubber cultivation. The farmers learned how to manage the rubber crop and how to tap the trees from their parents, since leaving elementary school. Consequently, the farmers managed their rubber plots in similar ways, based on what they had learned from their parents. All of the farmers had families with children still in school. This may have affected their willingness to apply new management practices.

Each of the three selected plots has its own story. Plot A was purchased 13 years ago, and it had been replanted with grafted improved material. The plants were cultivated using a monoculture system, fertilizer, and pesticides, and stimulant were applied, and weeds were controlled. Historically, the plot was rubber jungle. Instead of being cleared with mechanical machinery, it was cleared using the slash and burn system to turn over run-off soil, before being replanted. In the initial period, in the first 4 years when the rubber trees were young, the plot was cultivated with secondary seasonal crops such as banana, cassava, and chili, rather than the leguminous crops favored as soil covers in the larger plantations.

Plot B was purchased from another farmer, and was planted with unselected planting material. Plot C was gifted by the farmer’s parents, and was planted with unselected material. In plots B and C, fertilizers and pesticides were not applied, nor were weeds controlled, but coagulants were applied. Both plots contained many bushes, unknown timber trees, and fruit trees, and hence, were un-improved technology plots.

4.3 Yield, Costs, and Income

In this chapter, the important parameters considered are yield and income. Farmers tapped rubber trees to obtain latex sap three times per week, using the ½ sd/2 system[5], and sold the rubber slab once a week through farmer organizations. In the course of a year, the farmers had 2 or 3 weeks vacation, and so the trees are left untapped over this period. The yield was recorded weekly as kilograms of wet rubber[6]. Generally, there were higher yields from rubber trees in the rainy season (November–April) and lower yields in the dry season (May–October). Plot A produced higher yield/ha than did plot B and plot C (Figure 4.2). The yield fluctuated over the course of the year, which was possibly related to how the farmers managed the plots.

In this section, the three kinds of yield are explained: yield/area, yield/tree, and yield/labor hour. Based on the analyses conducted in this study, the yield/area was 3,828 kg/ha for plot A, 2,368 kg/ha for plot B, and 2,725 kg/ha for plot C (Table 4.3). That is, the yield/ha of plot B and C were 62% and 71% of that of plot A, respectively. The yield per tree in plot A was 7 kg/tree/year, higher than those in plot B (3.4 kg/tree/year) and plot C (4.5 kg/tree/year). The yield/labor hour in plot A was 4.4 kg/hour, higher than those in plot B (1.32 kg/hour), and plot C (4 kg/hour). These results clearly show that the plot in which improved technologies were applied produced higher yields. This finding is consistent with those of Collier and Werdaja (1972, p.79), who reported that farmers in Sumatra could not improve yields until they use improved clones. The yield per area was 13% (356 kg/ha) higher in Plot C than in Plot B.

The farmers applied various inputs in different quantities. For example, plot A was fertilized once per year at the start of the rainy season, pesticide was applied once, and grasses were weeded in the plot three times a year at irregular intervals. The other two plots received no fertilizer, pesticide, or weed control. Only a small amount of fertilizer was

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[5] ½ sd/2 system is tapping once every 2 days with a ½ spiral type.

[6] Yield at the farm level refers to wet rubber. The output from rubber trees is latex (milky liquid). After the rubber is sold and processed at a factory it becomes dry rubber. Therefore, at the factory level, rubber is 100% dry. The international price is set for dry rubber. The farm gate price of rubber is referenced to the international price by taking into account the dry rubber content (DRC), which is tested at the factory laboratory.

applied to plot A, 50 kg urea, instead of the recommended 492 kg mixed fertilizer (Amypalupy, 2008).

Farmers also applied stimulants at different frequencies and in various quantities. Stimulant was applied eight times per year in plot C, five times per year in plot B, and three times per year in plot A. Usually, farmers apply stimulants when their yields begin to decrease. Together with other input factors (tree age and fertilizer application), stimulants are one of the main factors affecting yield (Montgomery, 1978, p. 73).

Farmers use coagulants to produce slab rubber[7]. Latex naturally coagulates by itself after several hours, but farmers use coagulants to hasten this process. The type of coagulant can affect the quality of the rubber. The recommended/permitted coagulants consist of formic acid, while non-recommended/unpermitted coagulants include alum, sulfuric acid, and native root extracts (Barlow and Muharminto, 1982, p. 103).

Based on calculated costs[8], the costs were higher for plot A than for plot B and plot C. The average total cost of plot A was Rp 3.2 million/ha, more than three times higher than that of plot B and nearly twice that of plot C. The cost was 8.62% of total revenue (Table 4.4). Of the average total cost in plot A, Rp 2.5 million (78%) was spent on fertilizer, pesticide, and controlling grass weeds. No fertilizers were applied to Plot B and plot C. The small production costs due to use family labor to manage their plots (Wickizer, 1960).

Stimulants trigger the rapid release of latex from tapped trees. The cost of stimulant for plot C was Rp 0.7 million/ha, higher than for plots B and A (Rp 0.4 million/ha and Rp 0.3 million/ha, respectively). Besides the family labor cost, the stimulant cost was the highest cost for plots C and B (2.7% and 2% of total revenue, respectively). This finding was consistent with that reported by Montgomery (1978), who noted that private plantations that applied stimulants had production levels 28.4% higher than those from

[7] Slab rubber is a type of wet rubber, like cup lump and latex. Lump is solid latex that coagulates after several hours in the collecting cup. Slab rubber is a mixture of latex, cup lump, water, and coagulant. In the research area, slab rubber is generally rectangular, with a weight ranging from 20 to 40 kg. The thinner the slab, the easier it is to see imperfections; therefore, thinner slabs are generally of better quality. In the research area, most farmers produced slab rubber for ease of transport and selling.

[8] Current cost, not including seed cost or land cost.

plantations that did not use stimulants. However, excess use of stimulants can damage the trees if fertilizer is not applied to meet their nutrient needs.

The cost of the coagulant used in plot C was Rp 130 thousand/ha, slightly higher than that used in plot B (Rp 126 thousand/ha), and three times higher than that used in plot A (Rp 46 thousand/ha). The coagulant used in plots C and B was “deorub”, and that in plot A was a mixture of “deorub” and “cuka para”[9]. Technically, it takes more “deorub” than “cuka para” to coagulate the same quantity of slab rubber (latex, cup lump, slab). It was difficult to see differences in quality related to the coagulant, because the slab rubber looked the same. The type of coagulant also affected the output weight, as discussed later.

Finally, the income was higher for the plot A farmer (Rp 34.2 million/ha) than for the farmers in plots B and C (Rp 21.7 million/ha and 24.3 million/ha, respectively). The production costs were also higher for plot A than for plots B and C. The income included family labor.

The tapping labor is mainly provided by the family. In general, a husband and wife are assisted by their children to varying extents. Plot C required 14 h labor per week per ha, while plot A and plot B required 18 h and 36 h, respectively (Figure 4.3). The number of labor hours is related to the number of trees per hectare, farmer skill, and the plot conditions. In terms of farmer skill, out of 50 working weeks each year[10], a male worker was required for tapping for 32 weeks (64%) in plot C, while male and female workers tapped together for 18 weeks (36%). Plot A and B were tapped by male and female family members working together. According to interviews, tapping is six times faster with male family labor than with female family labor; therefore, female labor has lower productivity in terms of tapping. Less labor was required for plot C than for plots A and B. Plot B required more labor because the tree density was higher in plot B (678 trees/ha) than in plots A and C.

[9] “Deorub” is a permitted coagulant that consists of formic acid, whereas “cuka para” is an un-permitted coagulant consists of sulfuric acid.

[10] Out of 52 weeks a year, trees in plot A were tapped in 49 weeks, while those in B and plot C were tapped in 50 weeks.

4.4 Role of Improved Technology in Increasing Productivity and Income

Plot A had higher productivity than plots B and C. There were two main factors contributing to the higher productivity of plot A: the cultivation of HYV, and plot management (application of fertilizer and pesticide, and weed control). These two factors are related, because farmers that cultivate HYV tend to maintain their plantations more carefully than do farmers cultivating local varieties (LV). Plot A generated 3,828 kg yield/ha with a current input cost of Rp 3.2 million/ha. The yield from plot A was 38% and 29% higher than that from plot B and C, respectively (2,368 kg/ha in plot B, and 2,725 kg/ha in plot C). The current input cost in plot A was 74% and 61% higher than that in plot B and plot C, respectively (0.83 million/ha in plot B and 1.2 million/ha in plot C). The current input cost in plot A was only 8.6% of total revenue. The yield and income difference of plot A − plot B, plot A − plot C, and plot C − plot B show that improved technology is more efficient than unimproved technology in terms of producing yield and income (Table 4.5).

Comparing plot C and plot B, even though the trees in plot C were older than those in plot B, the yield/ha per area was higher in plot C because more stimulant inputs were applied. Stimulants were applied to plot C when the yield began to decrease. The farmers in plots B and C favored stimulant over fertilizer because stimulants can increase yield in the short term. However, applying stimulants without fertilizer or without controlling weeds can damage the health of the trees in the long term, potentially decreasing rubber production. Daily record data from plot C showed a decreasing trend in rubber production over the course of the year (Figure 4.2).

Comparing plot C and plot A, the stimulant cost was Rp 275 thousand/ha in plot A, 61% and 156% lower than that in plot C and plot B, respectively. Even though more stimulant was applied in plot C than in plot A, the yield in plot C was lower than that in plot A. This is because plot C was planted with a LV, no fertilizer was applied, and weeds were not controlled. This result indicates that applying more inputs such as stimulants can potentially increase yields from a LV, but its yield will still be lower than that from an HYV.

Applying improved technology potentially reduces the tapping time. The tapping labor/tree in plot A was 1.5 hour/tree/year, lower than that in plot B (2.6 hour/tree/year) but higher than that in plot C (1.1 hour/tree/year) (Table 4.3). Comparing plot A and plot B, the tapping time was shorter for the HYV than for the LV. This is because the trees were spaced at regular intervals in plot A, and there was clear access to each tree, making the tapping job easier and faster. The tapping time was longer in plot A than in plot C, because 64% of plot C was tapped by a male worker who could tap faster than the male and female workers in plot A.

The case of improved technology may an example of a high pay-off model in agricultural development, as mentioned by Schultz (1964) and Hayami and Ruttan (1985, pp. 59). Those authors noted that agricultural technology is highly location-specific, and that in most cases, techniques developed in advanced countries are not directly transferable to less developed countries with different climates and different resource endowments. In this case, the smallholder rubber farmers use the slash and burn approach to replant old rubber trees, intercrop during the gestation period, and apply a limited number of fertilizer, pesticides, and stimulants. These findings are consistent with those of Ketterings et al. (1999) and Tomich et al. (1998), who reported that the slash and burn approach is economically acceptable.

While Schultz (1964) and Hayami (1996) noted that agricultural technologies developed in advanced countries are not usually transferable to less developed countries, this does not imply that peasants in developing economies are tradition-bound, irrational creatures that cannot adopt new methods. In fact, peasant farmers are highly responsive to economic opportunities and are capable of using modern agricultural methods. In this context, Indonesian rubber farmers understand that applying HYV, fertilizers, pesticides, and stimulants are the way to increase yield.

4.5 Constraints to Applying Improved Technology

As discussed in the previous subchapter, cultivation of HYV and application of some management practices can result in higher yields than those obtained from the LV. This raises the question as to why the farmers in plots B and C have not planted HYV and changed their management practices. According to in-depth interviews with the farmers, the main reasons are the high costs of investment and maintenance. Investment in HYV requires the farmer to replant the entire plot. There are three issues with replanting: (1) the high cost of replanting, (2) the high cost of maintenance, and (3) the loss of income source for at least 5 years until the trees reach the tapping stage. These constraints are the same as those described by Barlow and Jayasurya (1984, p. 93). They reported that the cost of replanting would require all of the farmers' scarce cash, which is required to feed and educate their families. The approximate cost of replanting is Rp 8 million, excluding the extra costs of premium varieties and initial fertilizer. Most of the replanting cost is for labor, but the cost also depends on the location of the plot. It is cheaper to transport timber and input materials if the plot is close to a road, but more expensive if it is more distant from roads. Losing their source of income is an important constraint for farmers, because they have families to feed and educate. This is a particularly strong constraint if the rubber crop is the only source of income.

If the farmer replants with a HYV, each tree costs Rp 8,000, and is 1 year old (i.e., grown for 1 year after bud grafting). The HYV trees must be purchased from specific nurseries; that is, those of the Indonesian Rubber Research Center (IRRC) or certain nurseries registered with the IRRC. The farmer also has to maintain the rubber plot regularly until the trees reach the tapping stage (up to 5 years). Farmers who cultivate LV do not need to purchase trees from the IRRC, but use local varieties (unselected seedlings) either purchasing from unregistered nurseries or grown from unknown seeds. Some plots have trees that have grown from mature ovules that have fallen onto the ground. Because of this, rubber cultivation via seedlings is irregular and dense. Also, according to the interviews, farmers do not conduct regular maintenance before the trees reach the tapping stage. Instead, they tend the plot when the rubber trees are ready to tap.

Farmer A was able to replant plot A because he had more than one plot, and so he received income from other plots before the new trees reached the tapping stage. Also, plot A was located near a village road, and so it was easy to transport rubber logs (rest wood) to the market. The income from selling rubber logs offset the replanting cost. Also, Farmer A saved some of his rubber income to replant his plot. At that time, his dependents were still young and did not require much money for their schooling.

4.6 Conclusion

In this chapter, the role of improved technology in increasing rubber productivity from smallholding rubber farms in Indonesia was evaluated. The term "improved technology" covers the cultivation of HYV and the use of certain management practices. Three plots were selected for analysis: one with improved technology two without.

This small case study of three selected plots provided evidence that improved technology increased the rubber yield (per area, per tree, and per hour). Yield per area of HYV (plot A) was 3,828 kg/ha, higher than those from the local varieties in plots B and C (2,368 and 2,725 kg/ha, respectively). The HYV trees required current production inputs of Rp 3.2 million/ha, two or three times higher than those required for the LV. However, this cost was only 8.6% of total revenue (excluding family tapping labor cost). Comparing the two plots with LV, plot C had higher productivity per area than did plot B, because more stimulants were applied to plot C. Therefore, applying improved technology can increase the efficiency of rubber farms and increase farmer income.

Because of economic constraints, farmers sometimes use improved technology differently from how it is used in plantations. Specifically, farmers may (1) use a slash and burn approach to clear land, instead of a mechanical machinery system to turn over run-off soil; (2) cultivate secondary crops in the initial period—the first four years—instead of cultivating legumes as a soil cover crop, as is the case in plantations, (3) apply fertilizer at less-than-recommended doses, and (4) control grass weeds. Table 4.6 summarizes the yields obtained using these technologies.

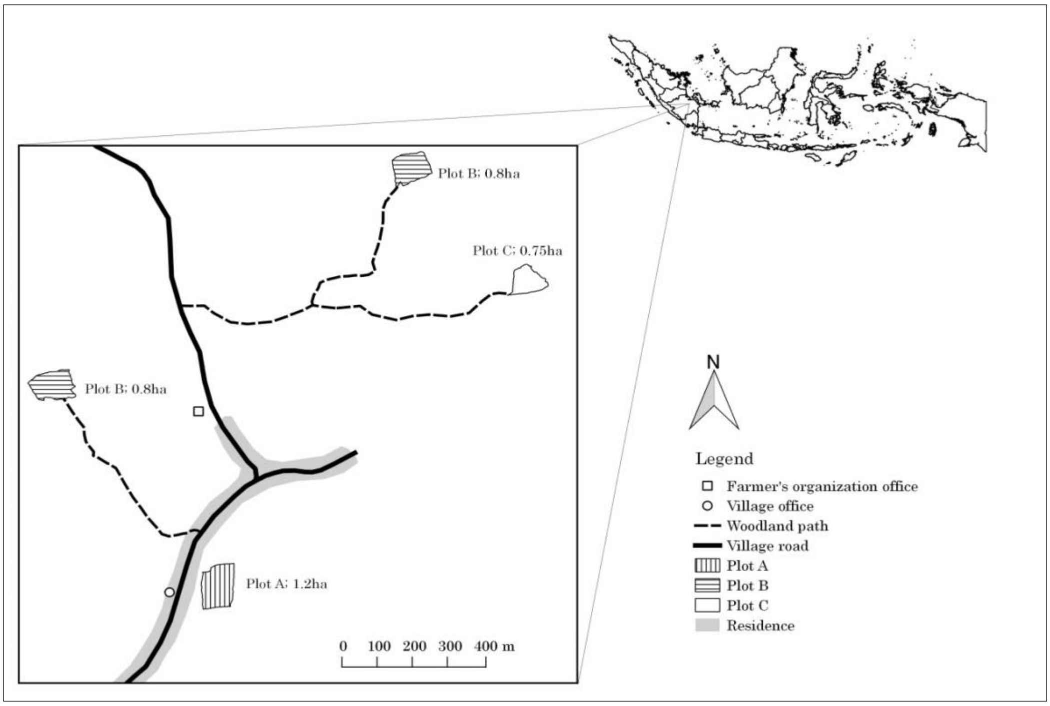
Farmers who use un-improved technology increase production by applying more stimulant, and sometimes, by increasing the rubber tree density. However, productivity is lower using un-improved technology than using improved technology.

Farmers whose rubber plots are located near a village road can feasibly replant with HYV. However, most smallholder rubber farms are located in more remote parts of jungles with poor road infrastructure. Therefore, one strategy to increase farmers' ability to replant is for the government to improve the road infrastructure (Barlow, 1997). One farmer replanted his old rubber trees using money saved from other plot income; this was possible because of less expensive school fees when his dependents were young. Therefore, because economic limitations can prevent smallholder rubber farmers replanting their crops, another strategy is for the government to provide credit for replanting costs. Of these two strategies, providing road infrastructure is more achievable than providing credit, because it is difficult for farmers to provide the land certificate that is essential for credit collateral.

Table 4.1 Details of study area.

Village Demographic	
Population (people)	653
Number of households	188
Number of rubber farmer households	163
Land area[a]	1,200
Rubber cultivation area[b]	423
Distance to provincial city, Palembang[c]	64
Distance to district city, Pangkalan Balai[c]	14
Number of farmer organizations	3
Temperature range[d]	25–34
Average farm size[e]	2.23

Source: Badan Pemberdayaan Masyarakat dan Pemerintah Desa (2012).
Notes: [a]Land area (ha) includes villager dwellings, village roads, public facilities, village river, and smallholder farms.
[b]Rubber cultivation area (ha) is area of rubber cultivation belonging to farmers in this village. Data are from village census in 2013.
[c]Values is km.
[d]Values are °C.
[e]Values is ha.



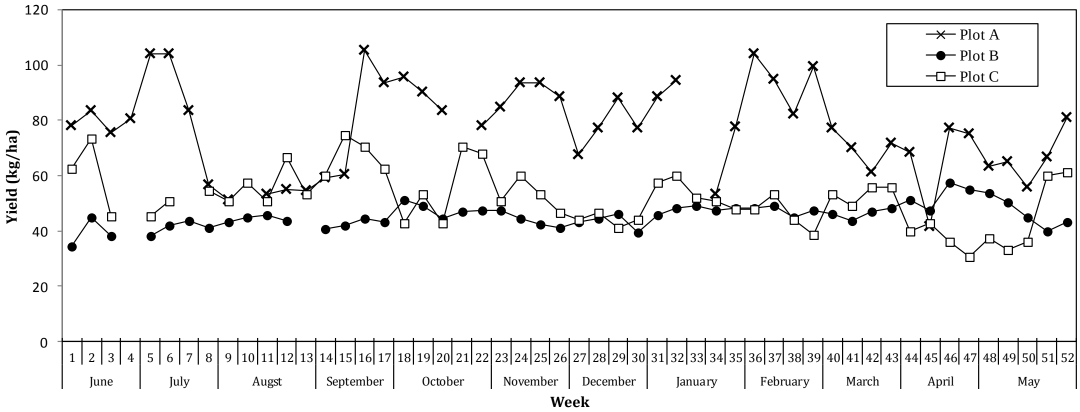
Source: Farm survey in 2013.

Figure 4.1 Map of three selected plots.

Table 4.2 Demographic conditions of selected rubber farmers in research area.

Farmer	A	B	C
Farmer average age[a]	43	50	46
Total area[b]	3.65	3.838	2.75
Number of plots	4	6	3
Selected plot[b]	1.2	1.622	0.75
Average age of rubber trees[a]	11	13	25
Number of trees in selected plot[c]	650	1,100	450
Variety[d]	HYV	LV	LV
Number of dependent family members in school	2	2	3
Period of engagement in rubber farms	1978–now	1970–now	1975–1985, 2009–now
Education	Senior High School	Elementary school	University
Side job	Treasurer of farmer group	Paddy farmer, tree cutter	Chairman of farmer group

Source: Farm survey in 2013.
Note: [a]Values are in year. [b]Values are in ha. [c] Values are in tree.
[d]HYV: high yield variety → GT 1 (Godang Tapen), PB 260 (Prang Besar); LV is local variety or unselected seedling.



Source: Daily farm record from 2013 to 2014.

Figure 4.2 Annual productions of three selected plots.

Table 4.3 Yield, labor, number of trees, and productivity of three selected plots.

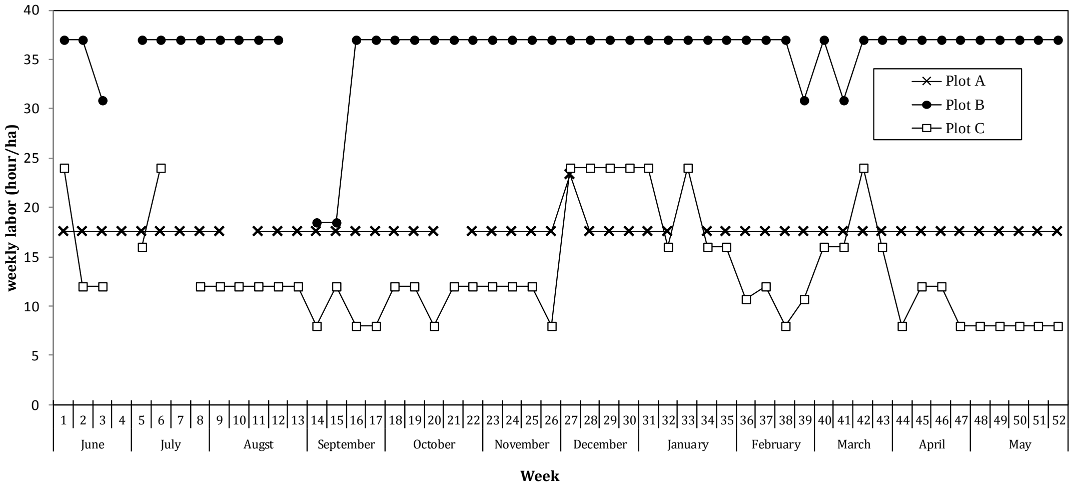
Farmer		Plot A		Plot B		Plot C	
Yield[a]	(1)		4,594		3,842		2,044
Tapping labor[b]	(2)		1,036		2,910		511
Number of trees in selected plot A	(3)		650		1,100		450
Area of selected plot[c]	(4)		1.2		1.62		0.75
Yield							
Yield per area[d]	(5)=(1)/(4)	3,828	(100)	2,368	(62)	2,725	(71)
Yield per tree[e]	(6)=(1)/(3)	7	(100)	3.4	(49)	4.5	(64)
Yield per labor hour[f]	(7)=(1)/(2)	4.4	(100)	1.32	(30)	4	(91)
Density[g]	(8)=(3)/(4)		541		678		600
Tapping labor[h]	(9)=(2)/(3)		1.5		2.6		1.1

Source: Daily farm record from 2013 to 2014.
Notes: [a]Values are kg. [b]Values are hour. [c]Values are ha. [d]Values are kg/ha. [e]Values are kg/tree. [f]Values are kg/hour. [g]Values are trees/ha. [h]Values are hour/tree.
Numbers in parentheses represent percentage of plot A.

Table 4.4 Revenue, costs, and income of three selected plots.

Farmer		Plot A		Plot B		Plot C	
Total revenue[a,d]	(1)	44,935	(100)	36,557	(100)	19,188	(100)
Total cost[d]	(2)=(3)+(4)(5)+(6)+(7)	16,307	(36)	36,274	(99)	7,069	(37)
Fertilizer, pesticide, and grass weeding cost[d]	(3)	3,050	(7)	0	(0)	0	(0)
Stimulant cost[d]	(4)	330	(1)	720	(2)	530	(3)
Coagulant cost[d]	(5)	55	(0)	204	(1)	97	(1)
Tapping tools cost[d]	(6)	440	(1)	430	(1)	310	(2)
Family labor cost[b,d]	(7)	12,432	(28)	34,920	(96)	6,132	(32)
Total Profit[d]	(8)=(1)−(2)	28,628	(64)	283	(1)	12,119	(63)
Revenue, cost, and income per land[c]							
Revenue per ha[e]	(9)=(1)/(4) Table 4.3	37,446	(100)	22,538	(100)	25,584	(100)
Cost per ha							
- Family labor included[e]	(10)=(2)/ (4) Table 4.3	13,589	(36)	22,391	(99)	9,425	(37)
- Family labor not-included[e]	(11)=(12)+(13)+(14)+(15)	3,229	(9)	834	(4)	1,250	(5)
Fertilizer, pesticide, and grass weeding cost per ha[e]	(12)=(3)/ (4) Table 4.3	2,542	(7)	0	(0)	0	(0)
Stimulant cost per ha[e]	(13)=(4)/ (4) Table 4.3	275	(1)	444	(2)	706	(3)
Coagulant cost per ha[e]	(14)=(5)/ (4) Table 4.3	46	(0)	126	(1)	130	(1)
Tapping tools cost per ha[e]	(15)=(6)/ (4) Table 4.3	367	(1)	265	(1)	413	(2)
Family labor cost per ha[e]	(16)=(7)/ (4) Table 4.3	10,360	(28)	21,555	(96)	8,176	(32)
Income[e]	(17)=(9)−(11)	34,216	(91)	21,703	(96)	24,334	(95)

Source: Daily farm record from 2013 to 2014.
Notes: [a]Revenue is the product of yield and price. Average price in this research is 9,891 Rp/kg.
[b]Family labor cost is product of family labor (hours) and wage rate in research area (12,000 Rp/hour).
[c]Revenue, cost, and income per hectare are values divided by selected plot area.
[d]Values are 000Rp. [e] Values are 000Rp/ha.
Numbers in parentheses in upper part represent percentage of total revenue, number of parentheses in lower part represent percentage of revenue/ha.
Exchange rate of 1 US$=Rp 12,135, October 2014.



Source: Daily farm record from 2013 to 2014.

Figure 4.3 Annual tapping labor in three selected plots.

Table 4.5 Differences in yield, cost, and income among three selected plots.

	Yield[a]		Cost[b]				Income[b]	
			Total cost		Stimulant cost			
Plot								
Plot A	3,828	(100)	3,229	(100)	275	(100)	34,216	(100)
Plot B	2,368	(62)	834	(26)	444	(161)	21,703	(63)
Plot C	2,725	(71)	1,250	(39)	706	(257)	24,334	(71)
Difference among plot								
Plot A – Plot B	1,460	(38)	2,394	(74)	−169	−(61)	12,513	(37)
Plot A – Plot C	1,103	(29)	1,979	(61)	−431	−(157)	9,882	(29)
Plot C – Plot B	356	(13)	425	(34)	262	(37)	2,631	(11)

Source: Tables 4.3 and Table 4.4

Notes: [a]Values are kg/ha. [b]Values are 000Rp/ha.

Numbers in parentheses in upper part are percentages of the value of plot A.

Numbers in parentheses in lower part are percentages of the difference between plots.

Table 4.6 Summary of yield according to technology used.

	Plot A	Plot B	Plot C
Category	Improved technology	Un-improved technology	Un-improved technology
Variety	HYV	LV	LV
Age of tree	Young	Old	Old
Fertilizer and pesticide	O (limited)	X	X
Grass weeding	O	X	X
Stimulant	O (low)	O (moderate)	O (high)
Yield/ha[a]	3,828	2,368	2,725

Source: Summarized from Table 4.4.
Notes: [a]Values are kg/ha.
O represents applying production input, X represents no input.

Chapter 5
Economic Analysis of Improving Slab Rubber Quality: A Case Study

5.1 Introduction

Indonesia is a key player in the global natural rubber market. In 2010, Indonesia produced 2.7 million tons of natural rubber, accounting for 26.3% of global rubber production (10.3 million tons; Food and Agriculture Organization, 2011). Indonesia is the second largest producer of natural rubber worldwide, competing with Thailand and Malaysia, which provide 31% and 11% of the global rubber supply, respectively. Approximately 85% of the rubber produced in Indonesia meets 21% of the international demand (Statistic Indonesia, 2011b). This demand has grown 5% annually as the result of GDP growth in the importing countries, and because of their willingness to reduce fossil fuel energy consumption.

Rubber-producing countries produce three main kinds of natural rubber: concentrated latex, RSS, and TSR[11]. Concentrated latex is the raw material for the gloves, thread, and condom industries, while the other two types are raw materials for the tire industry. In 2010, almost 95% of the total Indonesian rubber export was the TSR type, compared with 39% and 93% of rubber exported from Thailand and Malaysia, respectively (Table 5.1). Of the TSR type, 97% was the lowest grade, TSR 20, whereas TSR 20 rubber accounted for 75% and 51% of TSR-type rubber exported from Thailand and Malaysia, respectively. This percentage increased from 89% in 2004. The large proportion of low-quality rubber exported from Indonesia indicates that Indonesian rubber is becoming less competitive in the global natural rubber market. There are two possible reasons why Indonesia exports mainly low-grade rubber. First, there is an international demand for this type. Second, the raw materials produced by smallholder rubber farmers account for 85% of total production, and smallholder farmers can only produce low-grade rubber.

The problem of low-quality slab rubber at the farm level was studied by Barlow and Muharminto (1982). They reported that most farmers produced poor-quality slab rubber by

[11] Concentrated latex, RSS, and TSR are produced at the factory level. The direct output from rubber trees is the milky liquid, latex. Latex is processed into cup lump and slab rubber. Cup lump is solid latex that coagulates in the collection cup, while slab rubber is produced by mixing latex, cup lump, water, and coagulant. Concentrated latex and ribbed smoked sheet can be generated from latex, whereas TSR can be produced from latex, cup lump, and slab rubber.

applying non-recommended coagulants such as alum, sulfuric acid, or native root extract. Some farmers damaged their slab rubber by storing it under water. Barlow and Tomich (1991, p. 39) described that market imperfections and smallholder behavior were responsible for the lack of processes to improve quality. These conditions assumed that market imperfections allowed traders to keep bonus payments, rather than passing them on to farmers. Leimona et al. (2010) concluded that improving slab rubber quality could increase farmers' income when they sell their slab rubber to buyers and agents, who could gauge quality transparently and determine the price based on the dry rubber content. Furthermore, farmers may sell their slab rubber either to a village collector when there is a small quantity, or directly to a processing company if there is a larger quantity. Farmers who produce good-quality slab rubber may obtain a better price if they sell directly to a processing company than if they sell to a village collector. Arifin (2005) stated that the supply chain of natural rubber in Indonesia is very much determined by the industrial capacity of rubber processing companies, and by the efficiency of the marketing system that includes agents, farmers, traders, and rubber-processing companies. Traders play an important role in bringing slab rubber from the farmer to crumb-rubber factories, and in controlling the quality of the slab rubber. However, traders do not pay much attention to quality standards recommended by the government. Therefore, the overall quality of slab rubber has remained low (Napitupulu, 2011; Syarifa et al., 2013). Increasing the quality of rubber has been identified as one of the most important strategies to increase the competitiveness of rubber exports (Dradjat and Hendratno, 2009).

The government has released rubber quality standards via the Badan Standardisasi Nasional (National Standard Agency of Indonesia), namely, the Standard for Indonesian Rubber (SIR) at the factory level, and the Raw Material Standard (RMS) at the farm level. These standards are intended to increase rubber quality at both the factory and farm levels. The local government in South Sumatra has implemented a program to support farmers that use a particular permitted coagulant. This coagulant increases the quality of slab rubber, is not harmful to the environment, and reduces the unpleasant odor of slab rubber. However, there is still much to be done to improve slab rubber. In this chapter, the reasons for the continued production of poor-quality rubber are explored.

This chapter focuses on how farmers process their slab rubber. The main objectives are to explain why many farmers do not produce rubber to the RMS. In detail, this chapter aims to explain the achievement of farmers in producing slab rubber that meets the RMS; (2) to explain, in an economic context, why farmers choose not to process slab rubber according to the RMS; and (3) to investigate the main factors contributing to low rubber quality.

5.2 Definition of Rubber Quality

To explain rubber quality standards in detail, we must first define quality. The rubber quality standards were established by the national government as a type of guarantee system to ensure quality. The National Standardization Agency of Indonesia administers two rubber standards: SNI 06-1903-2000 (SIR) for rubber produced by processors; and SNI 06-2047-2002 (RMS) for slab rubber at the farm level.

5.2.1 Quality Standard at the Rubber Factory Level

Factories must produce rubber to the SIR for the international market, while rubber farmers should meet the RMS to sell slab rubber to the factory. The SIR specifies aspects of the raw material, processing, sizing, quality, packaging, and symbolization. The RMS includes only processing and quality standards.

Of the six standards within the SIR, the quality standard is the most decisive, because it covers purity (dirt content), ash content, evaporative substance content, plasticity retention index (PRi), and initial plasticity (Po) (Table 5.2). The purity is the maximum percentage of contaminants allowable (sand, leaves, branches, and mud). The standard specifies a maximum allowable ash content, to reduce heat build-up and control resistance to flex cracking. There is a maximum permitted content of evaporative substances, to control the amount of serum evaporation during processing. The PRi is the minimum permitted resistance to high temperature, and the Po is the minimum permitted plasticity at normal temperature. Rubber samples are tested in laboratories to determine whether they meet these standards.

5.2.2 Quality Standard at the Farm Level

Rubber production has two stages: the production of the raw material, slab rubber, by farmers; and processing of slab rubber into rubber by a processing company (factory). To produce SIR, the rubber factory needs raw material (slab rubber, latex, cup lump) that comes from their own plantations and from smallholder rubber farms. It is easier for the processing company to control the quality of the raw material from their own plantations than to control the quality of that produced by smallholder rubber farmers. Therefore, rubber processors need to impose a standard for the raw material that comes from rubber farmers.

The government released SNI 06-2047-2002 (RMS) for raw materials including latex, slab rubber, and cup lump. The standard covers the type of coagulant used, the purity and thickness of slab rubber, and the production method. Together, these factors represent a quality standard and a processing standard. The coagulant solidifies the latex. The purity refers to the dirt content in slab rubber. The thickness of slab rubber defines its grade. Finally, the production method refers to the processing standard followed to produce good slab rubber. The most important point of the processing standard is to dry the slab rubber for 1–2 weeks. The longer the drying time, the drier the slab rubber. The details of the standard are shown in Table 5.3.

5.3 Data and Selected Farmers

The objective of this chapter is to investigate why rubber farmers have not widely adopted the RMS. An economic analysis of rubber processing was conducted to investigate why producers favor low-quality slab rubber. The research was conducted in Pelajau Ilir Village, Banyuasin District, South Sumatra Province. This research area was selected because some farmers follow the RMS to process better-quality slab rubber, and some do not. The data were collected twice, in 2013 and in 2014.

The data were collected through detailed interviews with, and observations of, two farmers in a farmer organization. One produced slab rubber based on the RMS and the other did not. The data collected include the cost of coagulant, the weight loss during processing of slab rubber, and the weight reduction of slab rubber imposed by the trader; all of these factors are related to the processing and selling of slab rubber. The data do not include details of labor related to activities similar to those of rubber processing. Data were also collected from the farmer organization that sells rubber from the farmer to the trader. The trader (middleman) who buys slab rubber from the farmer through the farmer organization and sells it to the rubber factory was interviewed. Finally, data were collected from one farmer producing best- (premium-) quality slab rubber.

By observing how slab rubber is processed and by interviewing farmers, the quality of slab rubber produced can be determined by comparison with the RMS. Farmers who process slab rubber according to the RMS potentially generate best-quality slab rubber, while those who do not conform to this standard produce poor-quality rubber. This chapter also explains the economic behavior of farmers who produce different quality products.

5.4 Processing and Selling of Slab Rubber

5.4.1 Farmers' Achievements in Meeting the RMS

Before the 1970s, smallholder rubber farmers produced sheet rubber[12] (Collier and Werdaja, 1972), but they have produced slab rubber since then. This is because factory technologies improved to the stage where they could produce and sell TSR instead of only latex and RSS. These improvements in technology meant that factories could process a wider range of raw materials supplied by farmers. Accordingly, the factories could process any quality of slab rubber quality that farmers produced.

Before the RMS was introduced in the village, the farmers produced slab rubber in the same way as did their predecessors. They used unpermitted coagulants, the dirt content was not controlled, the slab rubber size was irregular, and slab rubber was regularly kept in the coagulating box or even in the river. After introducing the standard and receiving training to produce slab rubber based on the standard, some farmers began to process slab rubber based on the standard, but others did not. The farmers who processed slab rubber based on the standard only partially applied it (Table 5.4). The table shows the achievement of rubber farmers to produce slab rubber according to the RMS. Of the four attributes in the standard, farmers considered only two: the type of coagulant and processing. The slab

[12] Sheets are the raw material of RSS at the farm level. The size of sheets ranges from 3 to 5 mm.

rubber was often thicker than 150 mm (the lowest grade of the RMS), indicating that farmers did not pay attention to the thickness standard. Also, it was difficult to determine the purity (dirt content) of the slabs rubber because all slab rubber physically looked the same. Therefore, in this analysis, rubber quality did not include slab size or dirt content.

To produce high-quality slab rubber, the farmer needs to meet the RMS. However, few farmers comply with all of the stipulations of the standard. Based on observations, some farmers used the permitted coagulant and processed slab rubber partly based on the standard, but most farmers used unpermitted coagulant and did not process slab rubber according to the standard. Further discussion focuses on coagulant choice and processing.

In theory, as an economic agent, the farmer will respond to incentives to produce better-quality slab rubber. The decision whether to produce better-quality or poor-quality rubber depends on the net revenue (gross margin). Farmers will produce the type that gets the highest gross margin.

5.4.2 Processing Slab Rubber and Weight Loss

To understand the slab rubber processing undertaken by the farmers, the processing steps are explained in this section. Producing slab rubber includes four activities: tapping, collecting, coagulating (processing), and drying[13]. Slab rubber was produced and sold weekly in the study area (Figure 5.1).

The first two columns in Figure 5.1 give details of the slab rubber and plots, and the other seven columns show details of the weekly activity of processing slab rubber. In every plot, slab rubber was obtained by tapping trees three times per week using the ½ sd/2 system[14]. The slab rubber was collected and processed, and dried once a week. For the coagulation step, the coagulant was applied to hasten the solidification of latex and cup lump. The slab rubber produced using "cuka para" and dried for 4 hours before selling (on

[13] Tapping is the method of harvesting latex from the tree. The tapped latex flows into a collection cup and solidifies after several hours, hence it is called "cup lump". Collecting is when the farmers collect latex/cup lump from the cup into a bucket. Processing is the activity to process latex/cup lump into slab rubber by applying a coagulant. The process starts by diluting the coagulant in water and then adding the latex or cup lump to the coagulating box. Drying is when the slab rubber is removed from the coagulating box and dried. Selling is when farmers sell their slab rubber to traders via a farmer organization.

[14] The ½ sd/2 system is when trees are tapped once every two days with a ½ spiral type.

Thursday) is referred to as slab rubber *up4*; this was produced by Farmer X. Based on the RMS, this slab rubber is "poor quality". The slab rubber produced using the permitted coagulant, "deorub", and dried for 20 hours before selling is referred to as slab rubber *p20*; this was produced by Farmer Y. Based on the RMS, this slab rubber is "better quality".

The weight loss during drying was lower for *up4* than for *p20*. Table 5.5 shows the weight loss according to the quality of slab rubber. *up4* had a 10.9-kg weight loss from 138.9 kg output at the field level (or 7.85%), while *p20* had a 16.8-kg weight loss from 125.8 kg output at the field level (or 13.35%). *up4* was dried for only 4 hours while *p20* was dried for 20 hours. The longer the drying time, the greater the weight loss. Therefore, most of the slab rubber in the research area was stored saturated in coagulating boxes for several days, and dried only for a few hours before selling.

5.4.3 Selling Slab Rubber, Weight Reduction, and Effective Price

Most farmers in the village sell slab rubber to traders through farmer organizations. In the studied village, three farmer organizations organize the sale of slab rubber. The price of slab rubber set by the farmer organizations is decided by an auction system. In this system, traders bid for the slab rubber, taking into account its quality and the price at the factory level. The auction system is relatively new in the village, being introduced in 2009. Before the auction system, the selling system involved sub-district and district middlemen, resulting in a lower price at the farm level. In the auction, the middlemen compete with each other over price. This reduces the market power of the middlemen, and the farmer organization has more freedom to control buying and selling. The auction system has made rubber trading more efficient. The farmer organization sold 4 ton/week, collected from 62 farmers (i.e., 65 kg per farmer). The quantity per farmer was too small for farmers to sell directly to the rubber factory, located 64-km away from the village in Palembang. Therefore, farmers sell their rubber to the farmer organization.

In the farmer organization, the price of slab rubber is the same, regardless of its quality. At the time this study was conducted, the price of slab rubber was Rp 9,315/kg. However, the quality of slab rubber varies among farmers. Hence, the trader imposes a weight reduction to compensate for quality. The weight reduction is greater for poor-quality slab rubber than for better-quality slab rubber (Table 5.6). As shown in the table, *up4* faced a 7-kg weight reduction from 128 kg output at the market level (5.47% weight reduction), while slab rubber *p20* faced a 4-kg weight reduction from 109 kg output at market level (3.67% weight reduction). That is, the weight reduction imposed by the trader meant that there was a lower price for *up4* (Rp 8,806/kg) than for *p20* (Rp 8,973/kg). A higher price for better-quality slab rubber may provide the incentive for farmers to produce a better-quality product. The price after the weight reduction by the trader is the effective price.

5.5 Selling Output and Gross Margin of Slab Rubber

The main objective of this chapter is to conduct an economic analysis of processing slab rubber, focusing on the cost of processing slab rubber and the gross margin obtained from it. The processing cost was assessed based on the RMS. Farmers consider only two attributes of the standard: the choice of coagulant (point 1 in the standard) and the coagulant process, especially the drying time (point 4 in the standard). Therefore, the difference between the processing cost and revenue is based on these two factors. Because there is weight loss during drying and a weight reduction imposed by the trader at selling, there is a lower output at the selling level than at the field and market levels[15]. The selling output is shown in Table 5.7.a. As shown in the table, the selling output rate of *up4* (86.68%) was higher than that of *p20* (82.98%). Even though the weight reduction faced by *p20* was smaller than that faced by *up4*, the weight loss of *p20* was much higher than that of *up4*. Consequently, the selling output of *p20* was 3.7% lower than that of *up4*.

Revenue is obtained by multiplying the selling output by the price. The effective price takes into account the weight reduction, which is included in the selling output; then, to avoid double counting, the nominal price is applied, rather than the effective price. The gross margin is obtained by subtracting the coagulant cost from revenue. The coagulant cost was lower for *up4* (Rp 1,172/100 kg or Rp 12/kg) than for *p20* (Rp 8,257/100 kg or Rp 83/kg). The coagulant cost for *p20* was the cost after receiving a 40% government

[15] Output at the field level is output after the farmer dries the rubber from the coagulating box. Output at the market level is output at the farmer organization site, before being weighed by the trader. The selling output is the output after the rubber has lost weight via drying and via the weight reduction imposed by the trader.

subsidy (Rp 22,500/liter market price). To produce 100 kg slab rubber at the field level, only 100 ml "cuka para" is required, but 1,000 ml of "deorub". As shown in Table 5.7.b, the gross margin of *up4* (Rp 806,252/100 kg or Rp 8,062/kg) was 5% higher than that of *p20* (Rp 764,702/100 kg or 7,647/kg). This is because the selling output of *up4* was higher than that of *p20*, and the coagulant cost was lower for *up4* than for *p20*. For simplicity, the discussion below uses percentage and per kg.

Farmer Y dried the slab rubber 20 hours before selling, so that the weight reduction imposed by the trader would be as small as possible. Farmer Y was a board member of the farmer organization responsible for improving rubber quality according to the local government guidelines. Farmer X dried the slab rubber only 4 hours before selling to maximize the selling output, and expected that the trader could not distinguish the quality of the slab rubber.

5.6 Farmers' Options and Government Policy related to Slab Rubber Quality

The choice of the coagulant and the drying time are two factors that the farmer can control to maximize gross margin. Because farmers are rational thinking economic agents, they will process the slab rubber using the method that creates the highest gross margin. Some scenarios that explain gross margin based on coagulant choice and drying time have been proposed (Figure 5.2). The scenarios take into account drying time, coagulant choice, and government policy. The main objective of the farmer is to increase gross margin. However, the different scenarios affect slab rubber quality, leading to a higher or lower quality product.

1. Same coagulant, different drying times.
   - *up20*: slab rubber is produced using "cuka para", an unpermitted coagulant, and is dried 20 hours before selling. In this scenario, the farmer is processing to obtain better-quality slab rubber, but uses an unpermitted coagulant.
   - *p4*: slab rubber is produced using "deorub", a permitted coagulant, but dries slab rubber 4 hours before selling. In this scenario, the farmer uses a permitted coagulant, but an old processing method. The farmer receives a 40% subsidy of the coagulant price.

2. Government gives higher subsidies for permitted coagulant.

- *p20&s100*: slab rubber that being produced using permitted coagulant, and dried 20 hours before selling. The farmer receives a 100% subsidies of the coagulant cost.

Analyses of these scenarios can reveal which one maximizes farmers' gross margin, and explain why farmers choose to produce poor-quality slab rubber. Scenarios *up20* and *p4* produce poor-quality slab rubber, while scenarios *p20*&*s100* produces better-quality slab rubber. The predicted outcomes of each of these scenarios are shown in Table 5.8. As shown in the table, *up4* has the highest selling output rate and gross margin (86,68 % and Rp 8,062/kg, respectively).

Comparisons among the different scenarios can reveal details of how processing can affect farmer outputs and gross margin.

a. Comparison between *up4* to *p4* and *up20* to *p20*: different coagulant, same drying time.

This comparison shows how a different coagulant affects weight loss rate and weight reduction rate, and how these factors affect selling output rate and gross margin. *up4* was produced using an un-permitted coagulant with 4 hours drying time, while slab rubber *p4* was produced using a permitted coagulant, also with 4 hours drying time. The weight loss rate of slab rubber was 7.85% for *up4* and 8.33% for *p4*, a difference of 0.48% (Table 5.9, row 6). When these slab rubber products were sold to the trader in the farmer organization, the same weight reduction (5.47%) was imposed on both of them. Thus, the selling output rate and gross margin were 86.68% and Rp 8,062/kg, respectively, for *up4*; and 86.20% and Rp 7,946/kg, respectively, for *p4*. Therefore, the trader does not take into account the type of coagulant when applying the weight reduction.

The comparison between *up20* and *p20* shows the same trend. The weight loss of *up20* was 11.67% and that of *p20* was 13.35%, a difference of 1.68% (Table 5.9, row 7). This is because "cuka para", the unpermitted coagulant, makes the slab rubber retain a higher water content. The trader imposed the same weight reduction rate, 3.67%, on *up20* and *p20*. Therefore, the selling output rate of *up20* was 84.66%, higher than that of *p20*, 82.98%. The gross margin of *up20* was Rp 7,874/kg, higher than that of *p20*, Rp 7,647/kg.

Based on these comparisons, the weight losses of $up4$ and $up20$ were 7.85% and 11.67%, respectively. The weight losses of $p4$ and $p20$ were 8.33% and 13.35%, respectively. However, the same weight reductions rate are imposed by the trader; 5.47% for $up4$ and $p4$ and 3.67% for $up20$ and $p20$, regardless of the type of coagulant. That is, the trader does not take the type of coagulant into account when imposing the weight reduction.

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b. Comparison between *up4* to *up20* and *p4* to *p20*: same coagulant, different drying times.

up4 and *up20* were produced using the same unpermitted coagulant, “cuka para”, but the former was dried for 4 hours and the latter for 20 hours. The weight loss was lower for *up4* (7.85%) than for *up20* (11.67%), because *up4* was dried for a shorter time. Therefore, *up4* had a 3.82% smaller weight loss rate than that of *up20* (Table 5.9, row 8). Furthermore, the weight reduction rate imposed by the trader was higher for *up4* (5.47%) than for *up20* (3.67%). Therefore, the difference in the weight reduction rate between *up4* and *up20* was 1.8%.

Slab rubber *p4* and slab rubber *p20* were produced using the same permitted coagulant, “deorub” but the former was dried for 4 hours and the latter for 20 hours. The weight loss rate of *p4* (8.38%) was lower than that of *p20* (13.35%). That is, the weight loss rate was 5.02% lower for *p4* than for *p20* (Table 5.9, row 9). The weight reduction imposed by the trader was 5.47% for *p4* and 3.67% for *p20*. Therefore, the difference in the weight reduction between slab rubber *p20* and slab rubber *p4* was 1.8%.

Summarizing these two comparisons, the slab rubber produced using the permitted coagulant had a 5.02% difference in weight loss rate caused by different drying times (20 vs. 4 hours), while that produced using an unpermitted coagulant had a 3.02% difference in weight loss rate caused by different drying times. The unpermitted coagulant resulted in a higher water content in the slab rubber product, and therefore, a smaller weight loss rate.

c. Comparison between *up4* and *p20&s100*: government provides higher subsidies for coagulant.

up4 creates a gross margin of Rp 8,062/kg, which is higher than those created by *up20*, *p4*, and *p20&s40*. What would happen to the gross margin of *p20* if the government provided a 100% subsidy for the coagulant cost as an incentive to produce better-quality slab rubber? As mentioned above, the government currently subsidizes the coagulant cost (from Rp 22,500/liter at market price to Rp 9,000/liter at the subsidized price). If the government subsidized 100% of the coagulant cost, the cost for permitted coagulant would be Rp 0. Slab rubber *p20* is produced using a permitted coagulant and 20 hours drying time, with a weight loss rate of 13.35%, and a weight reduction rate of 3.67%. The selling output rate of the slab rubber is 82.98%. As shown in Table 5.9, the gross margin for *p20&s100*

would be Rp 7,729/kg, still lower than that of *up4*. In summary, even if the government subsidized 100% of the coagulant cost, the farmers would not produce better-quality slab rubber because it would not increase the gross margin to a level higher than the gross margin of *up4*.

Summarizing the present conditions and scenarios, *up4* generates the highest gross margin, Rp. 8,062/kg (Figure 5.3). This explains why farmers prefer to produce poor-quality slab rubber—it generates the highest gross margin.

5.7 Asymmetric Information Problem for Slab Rubber Quality

The analysis showed that farmers produce poor-quality instead of better-quality slab rubber to obtain the highest gross margin. The question is why does this practice continue?

One problem is that the weight reduction imposed by the trader is not based on sound information. The trader cannot tell exactly what quality of slab rubber the farmer has produced. The farmer cannot predict the size of the weight reduction imposed by the trader. The trader checks the quality of slab rubber by fingering and slashing on site, but this is a very rough and inaccurate checking method. As a result, the weight reduction favors Farmer X who produces *up4*, because its selling output rate (86.68%) is higher than that of *p20* (82.98%).

The scenario for *p20&s100* shows that even if the government subsidizes the entire cost of the permitted coagulant, the gross margin of the slab rubber product (Rp 7,729/kg) is still lower than that of *up4* (Rp 8,062/kg); therefore, the farmer will not use the permitted coagulant (a requirement of the RMS), even if it is fully subsidized.

The asymmetric information between farmers and traders results in cheating behavior. In this case, the farmer adds more water to the mixture, uses a coagulant that retains water in the slab rubber, and dries the slab rubber for only 4 hours before selling. The trader tries to impose the maximum weight reduction. In the study area, these behaviors were widespread and were based on the rational behavior of both farmers and traders to maximize their revenues and gross margins. The relationship among farmers, traders, and rubber factories is shown in Figure 5.4.

There is also asymmetric information with respect to the trader and the rubber factory. The trader usually transports slab rubber to the factory in a truck. Because there are variations in the quality of the slab rubber on the truck, the trader also faces a weight reduction at the factory level. The quality is checked by trampling and slashing a randomly selected rubber sample. Again, this checking system is imprecise and prone to errors. The weight reduction ranges from 5% to 10% of the total quantity. Almost all traders arrive at the rubber factory with slab rubber products that range in quality. Therefore, it is time consuming to check the quality, even roughly, for each truckload of slab rubber. This results in long waiting times for slab rubber loads to be assessed. In factory observations, it often took 5 hours for the quality to be assessed by workers at the factory, or longer than 12 hours when many traders came at the same time.

To compensate for the weight reduction at the factory, the trader tries to maximize the weight reduction he imposes on the farmer. Also, the traders try to hide the poor-quality slab rubber within the load on the truck, so that the factory will not notice it and apply a smaller weight reduction.

At the rubber factory, the poor quality slab rubber can be processed into SIR 10 or SIR 5, which are higher grades than SIR 20 (the lowest grade), but it is expensive. Therefore, most rubber factories produce SIR 20 instead of SIR 5 and SIR 10. To produce SIR 20, poor-quality and better-quality slab rubber are mixed at a ratio of approximately 9:1. The poor-quality slab rubber is mainly from small landholders supplying truckloads of product with varying quality, whereas the better-quality slab rubber is mainly from large-scale farms or plantations that supply truckloads of uniform-quality product[16].

5.8 An Accurate Checking System

An accurate checking system is required to equalize the gross margins of farmers producing poor-quality slab rubber and those producing better-quality slab rubber. In the case above, consider the gross margin of $up4$ and $p20$ (GM_{up4} and $GM_{p20\&s40}$), where GM_{up4} is Rp 8,062/kg and $GM_{p20\&s40}$ is Rp 7,647/kg. In ideal conditions,

[16] Personal communication, Rubber Research Center.

$GM_{up4} \leq GM_{p20\&s40}$. If the rule applies, then farmers will prefer to produce better-quality slab rubber to maximize their gross margin.

The gross margin is calculated from revenue minus coagulant cost (C); revenue is the product of selling output rate and output price; and selling output rate (SO) is output rate at field level (X) minus weight loss rate (WL) and weight reduction rate (WR). Because weight loss is technically unchanged because of the characteristics of the coagulant, it is difficult to equalize gross margin based on this parameter. Therefore, it is better to adjust the weight reduction based on an accurate checking system; then, GM_{up4} and $GM_{p20\&s40}$ can be equalized by adjusting the weight reduction. An accurate checking system can be achieved by either (1) adjusting the weight reduction rate to *p20* (WRA_{p20}) or (2) adjusting the weight reduction rate to *up4* (WRA_{up4}). The weight reduction can be formulated as follows:

$$GM_{p20\&s40} = GM_{up4}$$

$$P\left(X_{p20} - WL_{20} - WR_{p20}\right) - C_{p\&s40} = GM_{up4}$$

$$WR_{p20} = \frac{P\left(X_{p20} - WL_{p20}\right) - C_{p\&s40} - GM_{up4}}{P}$$

therefore, weight reduction rate adjusted to *p20* is:

$$WRA_{p20} = \frac{P\left(X_{p20} - WL_{p20}\right) - C_{p\&s40} - GM_{up4}}{P} \tag{5.1}$$

where WRA_{p20} is the weight reduction rate adjusted to slab rubber *p20*; WL_{p20} is the weight loss rate of 20 hours drying time, P is the nominal price, $C_{p\&s40}$ is the cost of permitted coagulant with 40% government subsidy, and $GM_{p20\&s40}$ is gross margin of *p20* with a 40% subsidy of the coagulant price.

The results of the calculation are shown in Table 5.10. The WRA_{p20} was −0.79%; because this is a negative number, and the necessary condition is $0 < WR < 100$[17], the WRA_{p20} cannot equalize the gross margins of *p20&s40* and *up4* ($GM_{p20\&s40}=GM_{up4}$). That is, even though if no weight reduction is imposed on *p20*, the $GM_{p20\&s40}$ will still be lower than that of GM_{up4}. Therefore, this adjustment to the weight reduction will not improve the gross margin of better quality rubber.

Another accurate checking system can be achieved by imposing a greater weight reduction to *up4*, WRA_{up4}, while the weight reduction to *p20* remains constant. By generating equalization $GM_{up4}=GM_{p20\&s40}$ therefore,

$$WRA_{up4} = \frac{P\left(X_{up4} - WL_{up4}\right) - C_{up} - GM_{p20\&s40}}{P} \tag{5.2}$$

where WRA_{up4} is the weight reduction rate adjusted to *up4*; WL_{up4} is the weight loss rate of 4 hours drying time, P is the nominal price, C_{up} is the coagulant cost of unpermitted coagulant, and $GM_{p20\&s40}$ is the gross margin of *p20* with a 40% subsidy of the coagulant price.

Equation 5.2 defines how to adjust the weight reduction to *up4*, while maintaining $GM_{p20\&s40}$. Based on this calculation, the WRA_{up4} is 9.93%. Imposing this weight reduction would equalize the gross margins of *up4* and *p20&s40* ($GM_{up4}=GM_{p20\&s40}$) (Table 5.10b) so that the system would be fair to each farmer. The WRA_{up4} calculated in equation 5.2 is almost twice that imposed at present (5.47%), or a 4.46% greater weight reduction.

$GM_{p20\&s40}$ is the gross margin of *p20* when the government provides a 40% subsidy of the coagulant cost. If the government does not subsidize the coagulant cost at all, how does this affect the gross margin of *p20*? (GM_{p20}). That is, what percentage weight reduction should be imposed on *up4* to equalize its gross margin to that of *p20*? Equation 5.2 can generate the value of this weight reduction for *up4*.

[17] The weight reduction is positive and lies between 0 to 100. If the weight reduction is zero, no weight reduction has been imposed by the trader (in the case of best-quality slab rubber).

Based on the calculation, the weight reduction that should be imposed on $up4$ to equalize gross margins between $up4$ and $p20$ is 11.26%, or twice the current weight reduction of 5.47%. That is, to equalize GM_{up4} and GM_{p20}, a higher weight reduction should be imposed on $up4$.

The explanations from Table 5.10 and Table 5.11 are illustrated in Figure 5.5. The figure shows that, to equalize $GM_{up4}=GM_{p20\&s40}$ and $GM_{up4}=GM_{p20}$, an accurate checking system must be applied by imposing greater weight reductions on $up4$ (9.93% and 11.26%, respectively). The higher weight reduction imposed by trader, the lower the gross margin for $up4$.

Because there are many farmers producing small quantities of slab rubber in the farmer organization, an accurate checking system for every farmer would be very costly. This is the transaction cost. There is also a transaction cost when traders sell slab rubber to the rubber factory.

5.9 A Case of Premium Quality Slab Rubber

As mentioned above, the farmer organization organizes the selling of slab rubber from the farmer to the trader through an auction system. In the study area, there were 62 farmers selling through the farmer organization, each producing an average of 65 kg slab rubber per week. Some farmers had already received training from local government to produce rubber based on the RMS, and some had not. Therefore, the quality of the slab rubber varied among the farmers in the farmer organization. The organization only organized the selling of slab rubber, and did not control slab rubber quality. Some farmers processed slab rubber at home, and others processed it in their rubber plot.

In one case, a farmer (hereafter, “Farmer Z”) produced premium-quality slab rubber with the permitted coagulant “deorub”, no dirt content, a thin slab size (approximately 15 cm), and 312 hours drying time before selling. This rubber is defined as slab rubber *p312crs*. The farmer was able to sell directly to the rubber factory. Sometimes, he sold it through a middleman for a premium price. The farm gate price for his slab rubber was Rp 8,800/kg, compared with Rp 8,100/kg for that produced by other farmers in the organization, a price difference of Rp 700/kg. Table 5.12 shows a detailed comparison of the gross margin per kg among *up4*, *p20*, and *p312crs*.

As shown in Table 5.12, the selling output of *p312crs* was 85%/kg, lower than that of *up4*, but higher than that of *p20*. The price of *p312crs* was higher than that of *up4* and *p20*, therefore, the gross revenue was higher. After subtracting the coagulant cost, the gross margin of *p312crs* (premium quality) was Rp 7,412/kg, higher than that of *up4* (Rp 7,009/kg) and *p20* (Rp 6,638/kg).

In the case of *p312crs*, no weight reduction was imposed because the product was drier. In the gauging process, the trader did not check the quality because he could see that the rubber was clean and of uniform size. In this case, an accurate checking system was unnecessary.

The question is, why was Farmer Z able to produce premium-quality slab rubber? Farmer Z produced 1.5–2 ton every 2 weeks, and processed it and sold it individually The large quantity was because of the large harvest area, 25 hectares. Farmer Z hired six workers for tapping and rubber processing. These six employees had worked for Farmer Z for a long time, and knew how to produce premium quality rubber. Farmer Z was able to monitor the processing stage because it was conducted near the house. Monitoring of slab rubber processing is an important factor for producing a premium-quality product.

5.10 Peer Monitoring to Improve Slab Rubber Quality

The price of premium-quality slab rubber was Rp 8,800/kg, 9% higher than that of poor- and better-quality slab rubber (Rp 8,100/kg). Therefore, the rubber factory is responsive to premium quality. The gross margin of the premium-quality rubber (*p312crs*) produced by Farmer Z was Rp 7,412/kg, 6% and 12% higher than that of *up4* and *p20* produced by Farmers X and Y in the farmer organization, respectively. This higher gross margin should be an incentive for farmers in the farmer organization to produce a premium-quality product. However, there are two reasons why it may be difficult for farmers in the farmer organization to produce a premium quality product. First, the farmers in the farmer organization produce only a small quantity per week (65 kg, compared with 1.5–2 ton every 2 weeks for Farmer Z). Second, most small landholders cannot monitor processing, whereas Farmer Z was able to oversee all of the processing steps.

The farmer organization did not monitor the quality of the slab rubber. The services of the farmer organization were (1) to organize the selling of slab rubber, and (2) to provide credit for the purchase of agricultural inputs or for living expenses. The lack of a monitoring role may allow the members of the farmer organization to produce slab rubber of any quality. Therefore, the quality varied among members and tended to be poor. A monitoring system can be applied collectively among members; this would allow each member to play a role in controlling quality (Cechin et al., 2013; Deng and Hendrikse, 2014; and Wang and Qin, 2012).

The farmer organization did not provide guidance to its members regarding the production of slab rubber based on the RMS. Based on an interview with the chairman of the farmer organization, in the 5 years since its establishment, there has been only one instance of farmers receiving guidance on how to produce RMS-quality slab rubber. This was conducted in 2011 by local government. Because of this situation, many farmers do not know how to produce slab rubber based on the RMS.

Providing guidance and monitoring quality could be comprehensive functions of the farmer organization, especially in rural communities where there are strong relationships between organizations and farmers. One example is the multi-purpose agricultural cooperatives in Japan that undertake multiple functions such as marketing, supply, finance, farming guidance, and other services (Kurimoto, 2004; Klinedinst and Soto, 1994; Esham et al., 2012; Yoshida, 2001; Prakash, 2000; Kawano, 1977). If the farmer organization was to provide such a comprehensive service, the members may have stronger interactions with each other, making it more feasible to improve slab rubber quality.

Peer monitoring would be a convenient and inexpensive way to monitor the processing of slab rubber in farmer organizations. If all of the members in the farm organization monitored the production and quality of slab rubber, the quality could be markedly improved. Then, it would be easier to make contracts between the farmers and rubber factories. In this case, the rubber factory would be able to trust the quality of the products supplied by the farmer organization. At the same time, the farmer organization would have an incentive to obtain a higher price.

5.11 Conclusion

This chapter describes an economic analysis of improvement of slab rubber quality at the farm level, and evaluates the main reasons for the low quality of slab rubber produced at present. To improve slab rubber quality, farmers should follow the procedures noted in the RMS (SNI 06-2047-2002 for slab rubber). The standard stipulates the type of coagulant to be used, the purity level, the thickness of the slab rubber product (150 mm maximum), and the drying time (1–2 weeks).

The data were collected from two farmers in a farmer organization, one who produced slab rubber partly based on the RMS (better quality) and who did not (poor quality). Data were also collected from traders and the farmer organization. Data was collected two times, 2013 and 2014. For comparison, data were collected from one farmer producing slab rubber based on the standard (premium quality). The data included details of the processing and selling of slab rubber, but not labor. When processing slab rubber, the farmer faces the cost of coagulant and weight loss by drying. Then, when selling to the trader, the farmer faces a weight reduction. A simple cost and revenue analysis was used to define the economic factors affecting slab rubber quality.

The analysis showed that the gross margin of the farmer who produced better-quality slab rubber ($GM_{p20\&s40}$) was Rp 7,640/kg, while that of the farmer producing poor-quality slab rubber (GM_{up4}) was Rp 8,062/kg. This is because the farmer producing better-quality slab rubber had a lower selling output rate because of much greater weight loss rate during the longer drying time, with a smaller weight reduction rate imposed by the trader at selling time. The weight loss rate for better-quality slab rubber was 13.35%, compared with 7.85% for poor-quality rubber; that is, the farmer producing better-quality slab rubber faced a 5.5% greater weight loss. The weight reduction rate imposed by the trader was 3.67% for better-quality rubber, compared with 5.47% for poor-quality rubber, a difference of 1.8%. Finally, the selling output rate at the field level was 82.98% for better-quality rubber, but 86.68% for poor-quality rubber. The farmer producing better-quality rubber had a lower selling output (by 3.7%). At the time of the survey, 2013, the price for poor- and better-quality slab rubber was the same, Rp 9,315/kg. In summary, the gross margin is lower for better-quality than for poor-quality slab rubber.

The reason for the lower gross margin for better-quality slab rubber is the inequitable practice of weight reduction, which arose as a result of asymmetric information among the farmers, traders, and rubber factories. The trader cannot tell exactly how the farmer has produced the slab rubber, and the farmer cannot predict the weight reduction that will be imposed by the trader. To address this issue, traders should check the quality of the slab rubber. However, because of labor and time limitations, the traders only roughly check quality. This unreliable checking system can mean that farmers producing better-quality rubber have a lower selling output rate than that of farmers producing poor-quality rubber. The same weight reduction practice also occurs when the trader sells slab rubber to the rubber factory.

To equalize the gross margin for better- and poor-quality slab rubber, an accurate checking system was suggested. An accurate checking system would mean that farmers producing poor-quality rubber would face a greater weight reduction rate. The weight reduction would take into account the weight loss, cost of coagulant, and the gross margin of better-quality slab rubber. Based on the calculation, to equalize the gross margins of *up4* and *p20&s40*, the weight reduction for poor-quality rubber should be at least 9.93%. However, such an accurate checking system would be costly to implement for many small farms with small outputs.

For comparison, we discussed the situation of Farmer Z, who was able to produce premium-quality slab rubber. Farmer Z used a permitted coagulant and produced uniform, thin, clean slab rubber that was dried for 312 hours before selling. Even though the weight loss of this slab rubber was 15%, higher than that of poor- and better-quality slab rubber (7.85% and 13.35%, respectively), this slab rubber had no weight reduction imposed. Therefore, the selling output rate was 85%, which was higher than that of better-quality slab rubber (82.98%) but lower than that of poor-quality slab rubber (86.68%). This premium slab rubber obtained a premium price, Rp 8,800/kg, much higher than those of poor- and better-quality slab rubber (Rp 8,100/kg in 2014). Finally, the gross margin of premium-quality slab rubber was Rp 7,412/kg, 6% and 12% higher than that of poor- and better-quality slab rubber (Rp 7,009/kg and Rp 6,638/kg, respectively). Farmer Z was able to produce premium-quality slab rubber because of the large volume produced on his farm, and because he was able to monitor processing. The slab rubber was processed by six trusted, experienced employees, at a site next to the main house. This situation allowed Farmer Z to easily monitor the processing steps. Because Farmer Z produced slab rubber according to the RMS, the trader gave a premium price and imposed no weight reduction. In this case, an accurate checking system was unnecessary.

At present, the farmer organization organizes the selling of slab rubber and provides credit to farmers, but it does not monitor slab rubber quality. Consequently, the quality of slab rubber varies among farmers and tends to be poor. Accordingly, a weight reduction is imposed by the trader. Peer monitoring within a farmer organization is one way to introduce a quality control system. If this is successful, then the quality of slab rubber in farmer organizations may increase to a level similar to that of the premium slab rubber produced by Farmer Z. If the farmer organization could guarantee a high-quality product, then it may be possible to eliminate the weight reduction when selling to the trader. In this case, an accurate checking system would be unnecessary.

Finally, an improvement in the quality of slab rubber in the farmer organization would not only result in a premium price, but also allow for contracts to be made with the rubber factory or trader.

Table 5.1 Volume of natural rubber exported by three main producing countries in 2004, 2006, and 2010.

Type and grade	Indonesia				Thailand				Malaysia			
	2004		2010		2006		2010		2006		2010	
Concentrated latex	12	(1)	13	(1)	556	(20)	556	(19)	60	(5)	48	(5)
RSS	146	(8)	60	(3)	939	(34)	719	(25)	5	(0)	11	(1)
TSR	1,707	(91)	2,228	(95)	1,069	(39)	1106	(39)	1064	(94)	839	(93)
SIR/STR/SMR 5	0	(0)	0	(0)	*15*	(1)	*9*	(1)	0	(0)	0	(0)
SIR/STR/SMR 10	*32*	(2)	*0*	(0)	*70*	(7)	*80*	(7)	*334*	(31)	*242*	(29)
SIR/STR/SMR 20	*1,524*	(89)	*2,164*	(97)	*719*	(67)	*828*	(75)	*501*	(47)	*431*	(51)
Other TSR	*150*	(9)	*64*	(3)	*281*	(26)	*199*	(18)	*229*	(22)	*165*	(20)
Other natural rubber	9	(0)	50	(2)	207	(7)	485	(17)	7	(1)	4	(0)
Total	1,874	(100)	2,351	(100)	2,772	(100)	2866	(100)	1136	(100)	901	(100)

Source: Statistic Indonesia (2005a, 2011b), Lembaga Getah Malaysia (2011), and Thai Rubber (2011).
Notes:
RSS: Ribbed Smoked Sheet. TSR: Technical Specified Rubber (SIR: Standard Indonesian Rubber, STR: Standard Thailand Rubber, SMR: Standard Malaysian Rubber). Other natural rubber includes balata, gutta, percha.
Values are 000 ton.
Numbers in parentheses are percentages of total in each column, while numbers in italic parenthesis are percentages of TSR.

Table 5.2 Standard Indonesian Rubber (SIR) for several grades according to SNI 06-1903-2000.

Quality Attributes	Grade[a]		
	SIR 5	SIR 10	SIR 20
Dirt content[b]	Max 0.05	Max 0.10	Max 0.20
Ash content[b]	Max. 0.5	Max. 0.75	Max. 1.00
Evaporative substances content[b]	Max. 0.80	Max. 0.80	Max. 0.80
PRi	Min 70	Min 60	Min 50
Po	Min 30	Min 30	Min 30

Source: National Standardization Agency of Indonesia (2000).
Note: [a]Grade is level of required standard for selling rubber in international market. SIR 5 is a higher grade than SIR 10 and SIR 20.
[b]Values are percentage.

Table 5.3 Raw Material Standard (RMS) for slab rubber according to SNI 06-2047-2002.

No	Attribute	Requirement
1	Coagulant type	Permitted coagulant[a]
2	Cleanness	No dirt content
3	Thickness of slab rubber[b]	Grade I ≤ 50 mm, Grade II = 51–100 mm, Grade III = 101–150 mm Grade IV > 150 mm
4	Processing	a. Dilute latex or cup lump in coagulating box. b. Add coagulant, stand for several minutes (depending on the coagulant), then pour slab out from coagulating box. c. Dry slab for 1–2 weeks (not saturated).

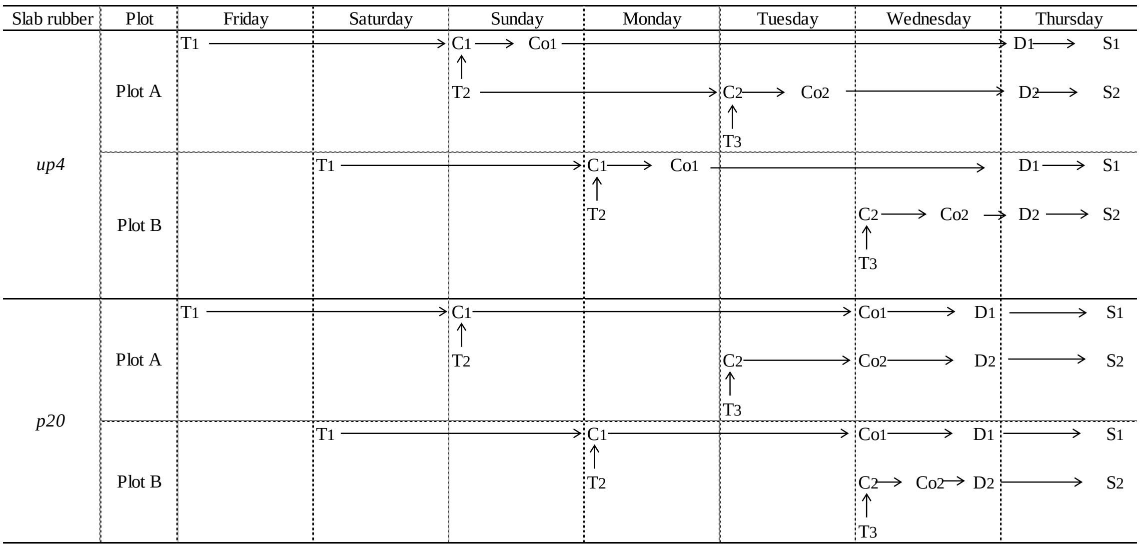
Source: National Standardization Agency of Indonesia (2002).
Notes: [a]Permitted coagulant consists of formic acid, rather than sulfuric acid, alum, and native root extract.
[b]Among four grades of slab rubber, Grade I is thinnest and highest grade, and grade IV is thickest and lowest grade. Thinner rubber is easier to check for cleanness.

Table 5.4 Farmers' achievement to process slab rubber according to Raw Material Standard.

No	Attribute	Requirement of RMS-Standard	Observation
1	Coagulant type	Permitted coagulant	"Deorub" and "cuka para"[a]
2	Cleanness	No dirt content	Difficult to measure
3	Thickness of slab rubber	Grade I ≤ 50 mm,	Farmers disregard this attribute
		Grade II = 51–100 mm	
		Grade III = 101–150 mm	
		Grade IV > 150 mm	
4	Processing	Dilute latex or cup lump in coagulating box	Farmers follow this process
		Add coagulant, stand for several minutes (depending on the coagulant) and then pour slab out from coagulating box.	Some farmers keep latex and cup lump for several days
		Dry slab for 1–2 weeks (no soaking/saturating)	Some farmers dry slab rubber very soon before selling (1 day or even hours)

Source: Farm survey in 2013.

Notes: [a]"Deorub" is an example of a permitted coagulant, "cuka para" is an example of an unpermitted coagulant. Achievement is based on observations of 62 rubber farmers in one farmer organization.



Source: Farm survey in 2013.
Note:
T: tapping; C: collecting; Co: coagulating; D: drying; S: selling.

Figure 5.1 Weekly schedules to process slab rubber.

Table 5.5 Weight loss of slab rubber according to quality.

		Observed quantity		Quantity per 100 kg	
		up4	*p20*	*up4*	*p20*
		Poor quality	Better quality	Poor quality	Better quality
Output at field level	(1)	138.9	125.8	100	100
Weight loss due to drying time	(2)	10.9	16.8	7.85	13.35
Output at market level	(3)=(1)−(2)	128	109	-	-

Source: Farm survey in 2013.
Note: Values are kg.

Table 5.6 Weight reduction and effective price of slab rubber according to quality.

		Observed quantity		Quantity per 100 kg	
		up4	*p20*	*up4*	*p20*
		Poor quality	Better quality	Poor quality	Better quality
Output at market level[a]	(1)=(3) Table 5.5	128	109	100	100
Weight reduction by trader[a]	(2)	7	4	5.47	3.67
Output after weight reduction[a]	(3)=(1)−(2)	121	105	94.53	96.33
Nominal Price[b]	(4)	9,315	9,315	-	-
Effective price[b]	(5)=(3)/(1)*(4)	8,806	8,973	-	-

Source: Farm survey in 2013.
Notes: [a]Values are kg. [b]Values are Rp/kg.

Table 5.7 Selling output rate and gross margin of slab rubber by quality.

a. Selling output of slab rubber according to quality.

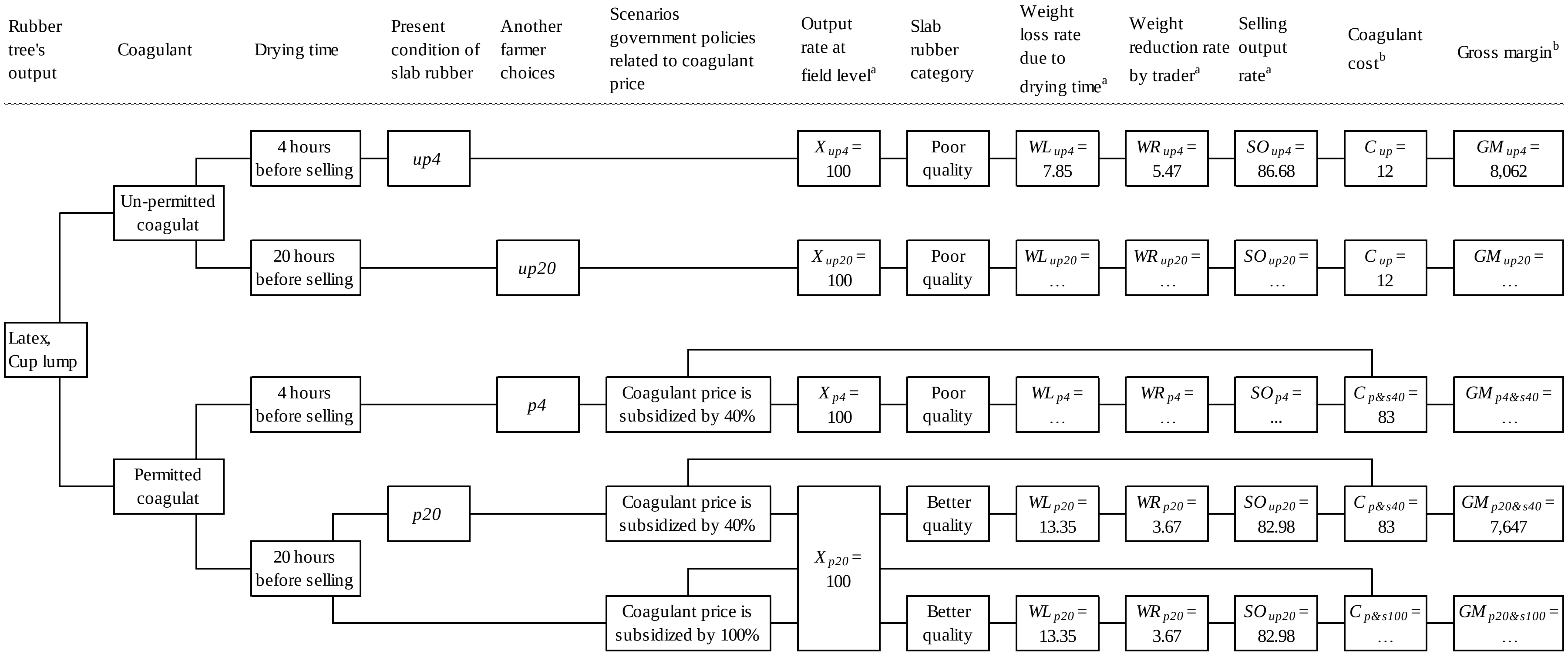
		up4	*p20*	Difference
		Poor quality	Better quality	*up4−p20*
Output rate at field level	(1)=(1) Table 5.5	100	100	-
Weight loss rate due to drying time	(2)=(2) Table 5.5	7.85	13.35	−5.5
Weight reduction rate by trader	(3)=(2) Table 5.6	5.47	3.67	1.8
Selling output rate	(4)=(1)−(2)−(3)	86.68	82.98	3.7

Source: Table 5.5 and 5.6.
Note: Values are percentage

b. Gross margin of slab rubber according to quality.

		up4	*p20&s40*	Difference
		Poor quality	Better quality	*up4−p20&s40*
Selling output rate[a]	(1)=a (4)	86.68	82.98	−3.7
Nominal price[b]	(2)=(4) Table 5.6	9,315	9,315	-
Revenue[b]	(3)=(1)*(2)	8,074	7,729	344
Coagulant cost[b]	(4)	12	83	−71
Gross margin[b]	(5)=(3)−(4)	8,062	7,647	415

Source: Table 5.5 and 5.6.
Notes:
up4: slab rubber produced using un-permitted coagulant; 4 hours drying time before selling.
p20: slab rubber produced using permitted coagulant; 20 hours drying time before selling.
p20&s40: slab rubber produced using permitted coagulant; 20 hours drying time before selling, and coagulant price is 40% subsidized by government.
[a]Values are percentage.
[b]Values are Rp/kg.



Notes:
[a]Values are percentage. [b]Values are Rp/kg.
up4: slab rubber produced using an un-permitted coagulant and 4 hours drying time.
up20: slab rubber produced using un-permitted coagulant and 20 hours drying time.
p4: slab rubber produced using permitted coagulant and 4 hours drying time.
p20 slab rubber produced using permitted coagulant and 20 hours drying time.
X: output rate at field level; WL: weight loss rate due to drying time; WR: weight reduction rate imposed by trader; SO: selling output rate obtained by subtracting output rate at field level to weight loss rate (WL) and weight reduction rate (WR); C: coagulant cost; C&S: coagulant cost subsidized by government; GM: gross margin. Values of X; WL; WR; SO are between 0 and 100, where WL+WR+SO = X = 100.
Nominal price of output is Rp 9,315/kg.

Figure 5.2 Processing scenarios and gross margin from slab rubber based on quality.

Table 5.8 Selling output and gross margin of slab rubber based on present conditions, farmer and government scenario.

a. Selling output of slab rubber according to quality.

Condition		Present conditions		Farmer options	
Slab rubber		*up4*	*p20*	*up20*	*p4*
Output rate at field level[b]	(1)	100	100	100	100
Weight loss rate due to drying time[b]	(2)=a (2) Table 5.7	7.85	13.35	11.67[a]	8.33[a]
Weight reduction rate by trader[b]	(3)=a (3) Table 5.7	5.47	3.67	3.67[a]	5.47[a]
Selling output rate[b]	(4)=(1)−(2)−(3)	86.68	82.98	84.66	86.2

Source: Tables 5.5 and 5.6.
Note: [a]Based on interview with farmer.
[b]Values are percentage.

b. Gross margin of slab rubber according to quality.

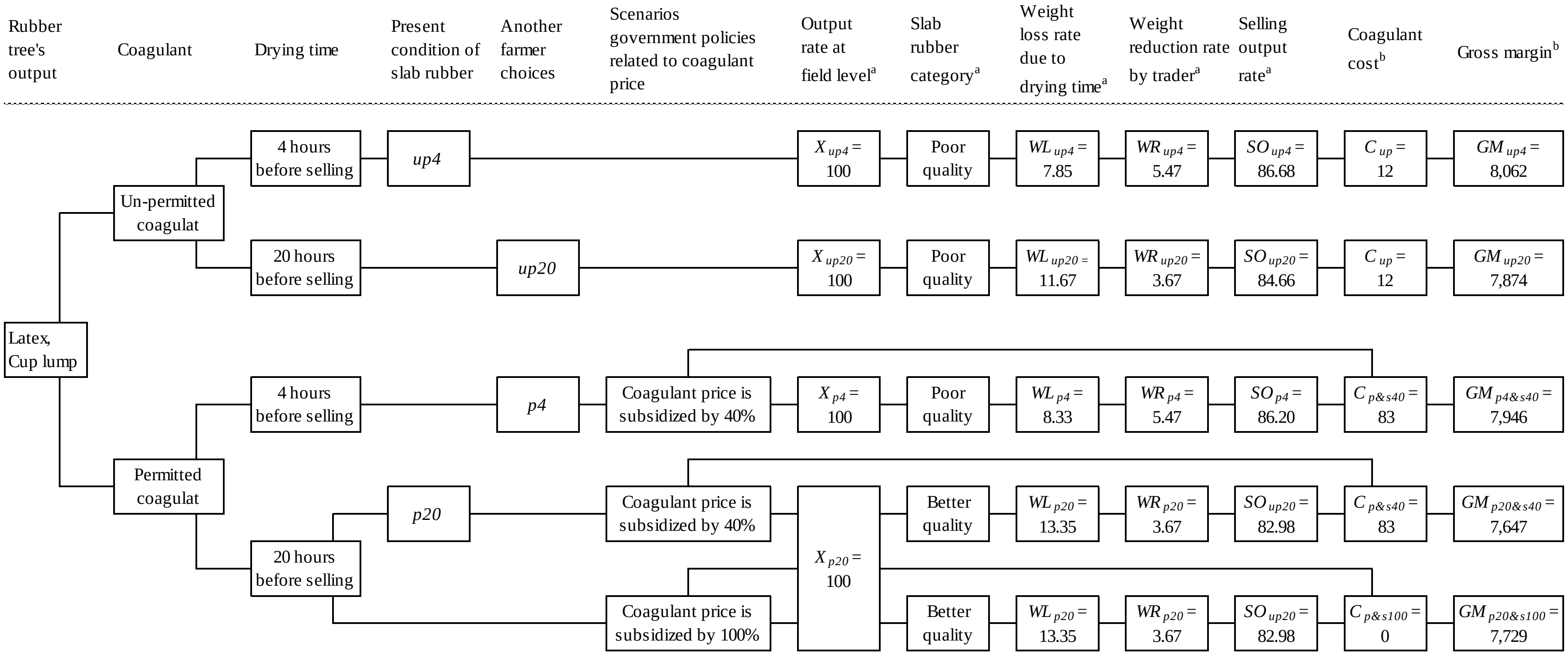
Condition		Present conditions		Farmer option and government scenario		
Slab rubber		*up4*	*p20&s100*	*up20*	*p4&s40*	*p20&s100*
Selling output rate[a]	(1)=a (4)	86.68	82.98	84.66	86.2	82.98
Nominal price[b]	(2)=(4) Table 5.6	9,315	9,315	9,315	9,315	9,315
Revenue[b]	(3)=(1)*(2)	8,074	7,729	7,886	8,029	7,729
Coagulant cost[b]	(4)	12	83	12	83	0
Gross margin[b]	(5)=(3)−(4)	8,062	7,647	7,874	7,946	7,729

Source: Tables 5.6 and 5.8a.
Notes:
[a]Values are percentage. [b]Values are Rp/kg.
up4: slab rubber produced using un-permitted coagulant; drying time 4 hours before selling.
up20: slab rubber produced using un-permitted coagulant; drying time 20 hours before selling.
p4: slab rubber produced using permitted coagulant; drying time 4 hours before selling.
p20: slab rubber produced using permitted coagulant; drying time 20 hours before selling.
p4&s40: slab rubber produced using permitted coagulant, drying time 4 hours before selling, coagulant cost 40% subsidized by government.
p20&s40: slab rubber produced using permitted coagulant, drying time 20 hours before selling, coagulant cost 40% subsidized by government.
p20&s100: slab rubber produced using permitted coagulant, drying time 20 hours before selling, coagulant cost 100% subsidized by government.

Table 5.9 Difference between selling output and gross margin of slab rubber based on quality and scenario.

		Weight loss rate[a]	Weight reduction rate[a]	Selling output rate[a]	Coagulant cost[b]	Gross margin[b]
Present conditions of slab rubber and scenarios						
up4	(1)	7.85	5.47	86.68	12	8,062
up20	(2)	11.67	3.67	84.66	12	7,874
p4&s40	(3)	8.33	5.47	86.2	83	7,946
p20&s40	(4)	13.35	3.67	82.98	83	7,647
p20&s100	(5)	13.35	3.67	82.98	0	7,729
Different coagulant, same drying time						
- *up4 – p4&s40* (4 hours)	(6)=(1)−(3)	−0.48	0	0.48	−71	116
- *up20 – p20* (20 hours)	(7)=(2)−(4)	−1.68	0	1.68	−71	227
Some coagulant, different drying time						
- *up4 – up20* ("cuka para")	(8)=(2)−(1)	−3.82	1.8	2.02	0	−188
- *p4&s40 – p20&s40* ("deorub")	(9)=(4)−(3)	−5.02	1.8	0.48	0	−115
Difference between present conditions and government policy						
- *up4 – p20&40*	(10)=(1)−(4)	−5.5	−1.80	3.7	−71	415
- *up4 – p20&s100*	(11)=(1)−(5)	−5.5	−7.88	3.7	12	333

Source: Calculation from Table 5.8.
Notes: [a]Values are percentage. [b]Values are Rp/kg.



Notes: [a]Values are percentage. [b]Values are Rp/kg.

Figure 5.3 Gross margin of slab rubber according to quality based on calculations and scenarios.

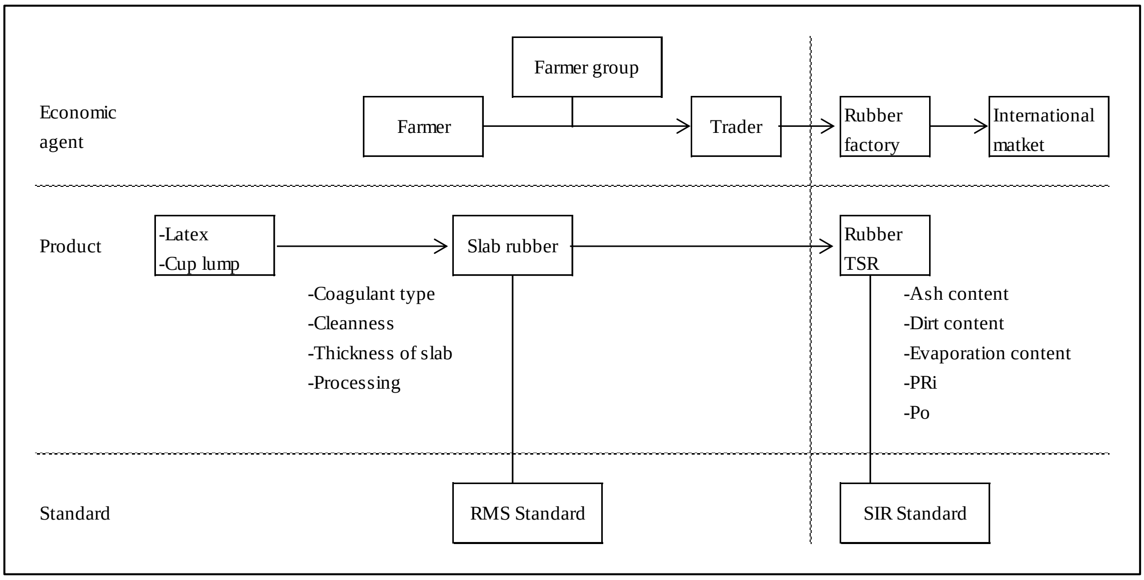


Figure 5.4 Flow of Raw Material Standard (RMS) and Standard Indonesian Rubber (SIR).

Table 5.10 Selling output rate, gross margin and weight reduction adjustment of slab rubber based on present conditions and accurate checking system.

a. Selling output and weight reduction adjustment according to quality.

Condition		Present conditions		Accurate checking system	
Slab rubber		*up4*	*p20*	*p20&WRA*	*up4&WRA*
Output at field level[c]	(1)	100	100	100	100
Weight loss rate due to drying time[c]	(2)=a (2) Table 5.7	7.85	13.35	13.35	7.85
Weight reduction rate by trader[c]	(3)=a (3) Table 5.7	5.47	3.67	−0.79[a]	9.93[b]
Selling output rate[c]	(4)=(1)−(2)−(3)	86.68	82.98	87.44	82.22

Source: Tables 5.5 and 5.6.

Notes:

[a] WRA_{p20}: weight reduction rate adjusted by trader or institution to slab rubber $p20$ to equalize gross margin to that of slab rubber $up4$.

$$WRA_{p20} = \frac{P\left(X_{p20} - WL_{p20}\right) - C_{p\&s40} = GM_{up4}}{P}$$

$$= \frac{9315(100-13.35)-83-8062}{9315}$$

$$= -0.79.$$

[b] WRA_{up4}: weight reduction rate adjusted by trader or institution to slab rubber $up4$ to equalize gross margin to that of slab rubber $p20$.

$$WRA_{up4} = \frac{P\left(X_{up4} - WL_{up4}\right) - C_{up} = GM_{p20\&s40}}{P}$$

$$= \frac{9315(100-7.85)-12-7647}{9315}$$

$$= 9.93.$$

[c] Values are percentage.

b. Gross margin of slab rubber according to quality.

Condition		Present conditions		Institutional approach scenario	
Slab rubber		*up4*	*p20&s100*	*p20&s100&WRA*	*up4&WRA*
Selling output rate[a]	(1)=a (4)	86.68	82.98	87.44	82.22
Nominal price[b]	(2)=(4) Table 5.6	9,315	9,315	9,315	9,315
Revenue[b]	(3)=(1)*(2)	8,074	7,729	8,145	7,658
Coagulant cost[b]	(4)	12	83	83	12
Gross margin[b]	(5)=(3)−(4)	8,062	7,647	8,062	7,647

Source: Tables 5.6 and 5.7a.

Notes: [a] Values are percentage. [b] Values are Rp/kg.

Table 5.11 Selling output rate, weigh reduction rate adjusted and gross margin of slab rubber without coagulant subsidy.

a. Selling output and weight reduction adjustment according to quality.

Conditions		No government subsidy	Accurate checking system
Slab rubber		*p20*	*up4&WRA*
Output rate at field level[b]	(1)	100	100
Weight loss rate due to drying time[b]	(2)=(2) Table 5.5	13.35	7.85
Weight reduction rate by trader[b]	(3)=(2) Table 5.6	3.67	11.26[a]
Selling output rate[b]	(4)=(1)−(2)−(3)	82.98	80.89

Source: Table 5.7.

Notes: [a]WRA_{up4}: weight reduction rate adjusted by trader or institution for slab rubber up4 to equalize gross margin to that of slab rubber $p20$ with no government subsidy.

$$WRA_{up4} = \frac{P\left(X_{up4} - WL_{up4}\right) - C_{up} - GM_{p20}}{P}$$

$$= \frac{9315(100 - 7.85) - 12 - 7523}{9315}$$

$$= 11.26.$$

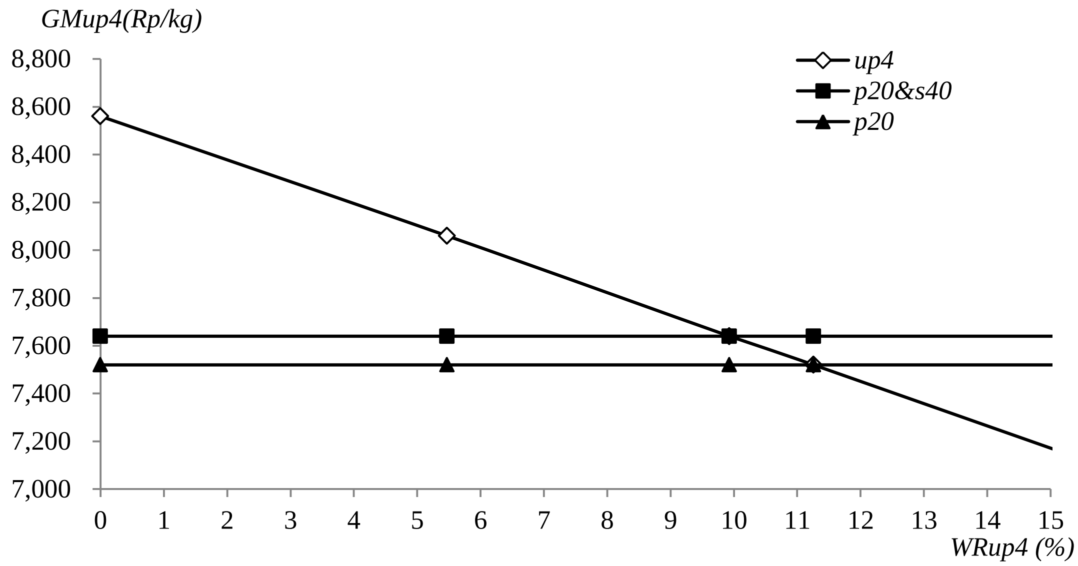
[b]Values are percentage.

b. Gross margin of slab rubber according to quality.

Conditions		No government subsidy	Accurate checking system
Slab rubber		*p20*	*up4&WRA*
Selling output rate[a]	(1)=a (4)	82.98	80.89
Nominal price[b]	(2)=(4) Table 5.6	9,315	9,315
Revenue[b]	(3)=(1)*(2)	7,534	7,534
Coagulant cost[b]	(4)	206	12
Gross margin[b]	(5)=(3)−(4)	7,523	7,523

Source: Table 5.7.

Notes: [a]Values are percentage. [b]Values are Rp/kg.



Source: Table 5.10 and Table 5.11.
Note: *GM*: gross margin, *WR*: weight reduction rate.

Figure 5.5 Weight reduction rates to slab rubber *up4* and its gross margin.

Table 5.12 Selling output, price and gross margin of poor-, better-, and premium-quality slab rubber.

Condition		*up4*	*p20*	*p312crs*[a]
		Poor quality	Better quality	Best quality
Output at field level[b]	(1)	100	100	100
Weight loss rate due to drying time[b]	(2)	7.85	13.35	15
Weight reduction rate by trader[b]	(3)	5.47	3.67	0
Selling output rate[b]	(4)=(1)−(2)−(3)	86.68	82.98	85
Output price[c]	(5)	8,100	8,100	8,800
Revenue[c]	(6)=(4)*(5)	7,021	6,721	7,480
Coagulant cost[c]	(7)	12	83	68
Gross margin[c]	(8) = (7)−(6)	7,009	6,638	7,412

Source: Farm survey in 2013 and 2014.
Notes: [a]*p312crs*: clean, thin (≤15 cm) slab rubber produced using permitted coagulant and 312 hours drying time.
[b]Values are percentage. [c]Values are Rp/kg.

Chapter 6
Summary and Conclusion

This study focuses on the effects of improved technologies on the income of smallholder rubber farmers in Indonesia. Smallholder rubber farms account for 85% of the total rubber cultivation in area in Indonesia, while private and government plantations account for the remaining 15%. However, the productivity of smallholder rubber farms (1,036 kg/year) is lower than that of private and government plantations (1,509 and 1,553 kg/year, respectively). Also, 92% of Indonesian rubber is exported as a low-grade product (SIR 20). Because most rubber comes from smallholder rubber farms, the farmers must be targeted to improve the grade of the rubber product. In this study, the term “improved technology” covers technologies related to cultivation of the rubber crop and processing to produce higher quality slab rubber.

The lower productivity and product quality may result in lower incomes for smallholder rubber farmers, and also lower average national income. In turn, the poor quality and low productivity can decrease the competitiveness of the Indonesian rubber sector in the international market.

This study comprehensively explains the natural rubber crop in Indonesia. Several local and international studies have focused on this topic, but from different points of view. In this study, the comprehensive analysis focused on the rubber crop from both a macro and micro point of view, and the detailed analyses revealed the daily activities of rubber farming and rubber processing on several different farms.

The findings of this study provide useful background data for related research, and provide policy recommendations related to the development of rubber farming in Indonesia. The agricultural development policies recommended here focus on the design and implementation of a rational program.

The main objective of this research is to explain the effect of improved technologies on the income of smallholder rubber farmers in Indonesia. The objectives are to: (1) describe the role of the rubber crop sector in Indonesian economic development; (2) explain socio-economic conditions of rubber farmers and their income; (3) conduct an economic analysis of the effects of improved technology on land, tree, and labor productivity and income; and (4) investigate factors that affect the quality of slab rubber produced by smallholder rubber farmers.

Primary data, secondary data, and data from field work were analyzed to address each of the objectives. To address the first objective, the role of the rubber crop sector in the Indonesian economy was analyzed based on data from the Indonesia input–output tables in 1995 and 2005 (Statistic Indonesia, 1999, 2007). Primary data were analyzed to address the second objective; that is, the social-economic conditions of rubber farmers and their income. The primary data were from the Survei Pendapatan Petani (Statistic Indonesia, 2004b) and Survei Sosial Ekonomi Nasional (Statistic Indonesia, 2005b). To address the third objective, farm record data from field surveys were analyzed to determine the effects of improved technology on productivity and income. Finally, to address the fourth objective, field data were analyzed to investigate the factors affecting the quality of rubber produced by smallholder farmers.

The field work related to the third and fourth objectives was conducted in Plajau Ilir Village, Banyuasin III Sub District, Banyuasin District, South Sumatra Province, one of the main rubber-producing regions in Indonesia. The region is located 64 km west of Palembang, the provincial city of South Sumatra. This region was selected because some of the farmers apply improved technology to cultivate and process rubber, while others do not. Two field studies were conducted, one in 2013 that focused on rubber quality, and one in 2014 that focused on the role of improved technology in increasing productivity.

The first objective focused on the role of the rubber crop sector from a macro point of view. The significance of the rubber crop in the Indonesian economy is explained in terms of the share the sector in economy backward and forward linkages, and multiplier effects. The results showed that in 1995, the share of the rubber sector out of total gross output, wages and salaries, and value-added in the Indonesian economy was 0.38%, 0.97%, and 0.50%, respectively. These were small proportions of the total Indonesian economic sector, but larger than those of other agricultural sectors, especially estate crop sectors. Among the agricultural sector, the rubber crop sector made greater contributions to gross output, wages and salaries, and value-added than did the palm oil sector (0.28%, 0.30%, and 0.39%, respectively), but lower contributions than those of the paddy sector (2.37%, 2.17%, and 3.7%, respectively), and the vegetable and fruit sector (1.62%, 1.29%, and 2.75%, respectively). The proportions of gross output, wages and salaries, and value-added were slightly lower for the rubber crop sector in 2005 (0.41%, 0.95%, and 0.57%, respectively). Therefore, within a decade, the share of gross output and value-added had increased, but the share of total wages and salaries had decreased. The increase in gross output may be because of increased quantity or price. Increased quantity can result from applying more production inputs and/or by increasing the cultivation area.

In 1995, the value of backward and forward linkages was 0.891 and 0.890, respectively. Because these values were less than 1, the sector showed low linkage to other sectors. The low backward linkage value means that the rubber crop had a poor ability to attract other sectors as inputs. The low forward linkage value means that the rubber crop had a poor ability to push other sectors. This is because a large share of the output is allocated to meet export demand without further processing in the domestic market. The same conditions are also faced by the vegetable and fruit and palm oil sectors. The paddy sector had a forward linkage value higher than 1; therefore, it was strongly dependent on other sectors (e.g., as the raw material for the rice milling sector). In 2005, the backward linkage value of the rubber sector had decreased slightly from 0.891 to 0.884, indicating that the ability of the rubber crop sector to attract other sectors as inputs had decreased slightly. This might be because farmers were still using conventional methods to cultivate rubber crops while expanding the rubber cultivation area, or because farmers did not apply proper production inputs. However, the forward linkage value of the rubber sector had increased from 1995 to 2005, from 0.890 to 0.943, indicating that this sector had a greater ability to push another sector, such as domestic rubber manufacturing.

In 1995, the multiplier effect of output, wages and salaries, and value-added was 1.358, 0.020, and 0.015, respectively. The value of 1.358 means that increasing one rupiah of final demand will increase gross output by Rp 1.358. The value is low as a proportion of all economic sectors, but is higher than those of other parts of the agricultural sector, such as the paddy, vegetable and fruit, and palm oil sectors (1.207, 1.123, and 1.362, respectively). In 2005, the multiplier of output had increased to 1.392, but those of wages and salaries and value-added were almost unchanged (0.02 and 0.015, respectively).

The backward and forward linkages of the rubber sector were 0.891 and 0.884, respectively, in 1995, and 0.890 and 0.943, respectively, in 2005. These are categorized as low values, which means that the rubber crop sector has low power to attract other sectors as inputs and to push other sectors as demands. This finding suggests that an improvement in the rubber crop can be achieved by pulling other sectors, for example, by applying more production inputs.

The second objective addressed the general conditions of rubber farmers in Indonesia and their income based on data from the Survei Pendapatan Petani (Statistic Indonesia, 2004b) and the Survei Sosial Ekonomi Nasional (Statistic Indonesia, 2005b). Summarizing these data, in 2004, 72.2% of smallholder rubber farmers had a low education level; 43.4% completed elementary school, and 28.8% had no schooling. The average family has 4.4 members, who may provide some or all of the farm labor. The average land area of smallholder farms is 2.3 ha, or, on a per-capita basis, 0.52 ha. For comparison, the average land area of paddy, maize, and palm oil farmers is 0.23, 0.20, and 0.60 ha per capita, respectively.

Additionally, the per-capita income of rubber farmers is Rp 3.1 million, higher than those of paddy and maize farmers (Rp 2.1 and 1.8 million, respectively), but lower than that of palm oil farmers (Rp 4.3 million). Rubber farmers rely on the rubber crop, because it contributes 49% of their total income. Rubber farmers may live in rural areas. The per-capita consumption of households in rural areas is Rp 2.4 million; 62% of consumption is for food, and 38% is for non-food items.

The third objective focused on the role of improved technology in increasing rubber productivity of smallholder rubber farms in Indonesia. “Improved technology” refers to cultivation of HYV, application of fertilizer and pesticide, and control of grass weeds. Three plots were selected for in-depth analyses: one that used improved technology, and two that did not. This small case study provided evidence that improved technology markedly improved rubber productivity per hectare, per tree, and per labor hour. The rubber productivity of land planted with HYV was 3,828 kg/ha; this value was 62% and

40% higher than the productivity of land planted with young LV rubber trees and old LV rubber trees (2,368 and 2,725 kg/ha, respectively). To increase productivity, cultivation of HYV requires a current production input of Rp 3.2 million/ha, which is two to three times higher than those required for the LV. However, this cost is only 8.6% of total revenue (excluding tapping labor costs, i.e., family labor). Therefore, using improved technology can increase the efficiency of rubber farms and increase farmer income to Rp 34 million/ha, which is higher than that of farmers using conventional technology (Rp 21 and Rp 24 million/ha for farmers cultivating young and old LV trees, respectively).

Compared with plantations, small landholder farmers adopt improved technology in a different way. The farmer in this study did not use machinery to turn over the run-off soil when replanting his crop, and cultivated seasonal crops during intercropping instead of the leguminous crops favored in plantations. Also, he applied fertilizer at a lower rate (50 kg/year, rather than the recommended, 492 kg/ha/year). Two of the farmers in this case study neither grew HYV nor maintained their rubber plantation by applying fertilizers/pesticides. This was because of the high cost of replanting and maintenance, and the loss of income before the trees reached maturity. The farmer who used improved technology was able to replant his plot because he earned additional income from selling rubber wood (log rubber). It is economically viable to sell log rubber from plots close to roads, but not from plots that are more distant from roads because of the high transport costs. Also, the farmer who replanted his plot was able to pay for the new seedlings using money saved while his dependents had low education expenses.

Farmers applying improved technology receive a higher income (Rp 34 million/ha) than did farmers using conventional technology (Rp 21–24 million/ha). Therefore, it is advisable to use improved technology to increase productivity and farmer income. However, it can be difficult for farmers to implement the improved technology, because of the high costs of replanting and maintenance, and the loss of living expenses while the crop is growing. The farmer who adopted improved technology was able to replant because of additional income earned from selling rubber wood (log rubber). This was only profitable because he was near a road and so his transport costs were low. Therefore, it is advisable to develop road infrastructure to increase the ability of farmers to replant old plantations.

Better road infrastructure, and consequently, better transport links, would make it economically viable to sell log rubber from plots that are distant from villages. In a macroeconomic context, providing road infrastructure is a way for the government to make a net contribution to the capital requirement for infrastructure (Johnston and Mellor, 1961). Also, because it is expensive to replant, the government could provide credit for farmers to replant their old rubber plots. Of the two recommendations, establishing road infrastructure is more reasonable than providing credit, because providing credit requires collateral from the plot certificate, which many farmers do not have.

The fourth objective focused on how to increase rubber farmers' income by increasing slab rubber quality. This chapter provided an economic analysis of slab rubber processing at the farm level, and identified the main reasons why farmers favor the production of low-quality slab rubber. In this context, "improved technology" means processing slab rubber according to the RMS at the farm level. The main points of the standard are to produce slab rubber with a permitted coagulant, a low level of contaminants, a maximum thickness of 150 mm, and a drying time of 1–2 weeks.

Detailed data were collected from two farmers in a farmer organization. Farmer X produced poor-quality rubber that was not based on the RMS, while Farmer Y produced slab rubber partly based on the RMS (better quality). The data included costs related to processing and selling of slab rubber, excluding family labor costs. The costs incurred during processing were the coagulant and the weight loss rate during drying time, and that incurred during selling was the weight reduction by trader being imposed to farmer. Data were also collected from a farmer organization and a trader. As a comparison, data were collected from Farmer Z, who produced best-quality slab rubber based on the RMS. A simple cost and revenue analysis was conducted to discuss improvements in slab rubber quality from an economic perspective.

The analysis showed that the gross margin of farmers producing better-quality slab rubber was Rp 7,647/kg. This was lower than the gross margin of the farmer producing poor-quality slab rubber (Rp 8,063/kg). The lower gross margin is the main reason why rubber farmers are reluctant to produce better-quality slab rubber. The lower gross margin resulted from the lower selling output rate and the higher coagulant cost. The selling output rate of better-quality slab rubber was 82.98% (100%−17.02% weight loss rate and weight reduction rate), which was lower than that of poor-quality slab rubber, 86.68% (100%−13.32% weight loss rate and weight reduction rate). The weight loss rate for better-quality slab rubber was 13.32%, 5.5% higher than that for poor-quality slab rubber, 7.85%. The weight reduction rate imposed by the trader was 3.67% for better-quality rubber, and 5.47% for poor-quality slab rubber, a difference of 1.8%. In total, the farmers producing better-quality slab rubber faced a loss in selling output of 17.02%, compared with 13.32% for farmers producing poor-quality rubber. Therefore, the difference in selling output between better- and poor-quality slab rubber was 3.7%. Also, the coagulant costs were more than six times higher for producing better-quality slab rubber than for producing poor-quality slab rubber (Rp 83/kg and Rp 12/kg, respectively). This finding confirmed that the gross margin of better-quality slab rubber is lower than that of poor-quality slab rubber.

The lower selling output rate of the farmer producing better-quality slab rubber may result from the inaccurate checking by the trader before imposing the weight reduction. That is, the trader checked the slab rubber by fingering and slashing a sample of the product. This inaccurate checking system may favor farmers producing poor-quality slab rubber. In other words, the inaccurate checking system by traders rose from asymmetric information among farmers, traders, and rubber factories. The trader cannot tell exactly what type of slab rubber the farmer has produced, and the farmer does not know exactly what weight reduction will be imposed. The trader tries to check the quality of the slab rubber, but this is often inaccurate because of limited time and arbitrary testing methods. Because of this inaccurate checking system, the better-quality rubber achieves a lower selling output than does lower quality rubber, by as much as 3.7%. The same weight reductions are imposed when the trader sells the slab rubber to the rubber factory.

To reward farmers that produce better-quality slab rubber, the checking system could impose a weight reduction on farmers producing poor-quality products, to the point where the gross margin of poor-quality slab rubber is the same or less than that of better-quality slab rubber; that is, $GM_{up4} \leq GM_{p20\&s40}$. To achieve this, the adjusted weight reduction for poor-quality slab rubber is 9.93%. However, applying this accurate checking system to small-scale farmers or factories that deal with multiple traders would be expensive in terms of time and labor.

Farmer Z produced a premium quality product with a gross margin of Rp 7,412/kg, 6% and 12% higher than those of poor- and better-quality slab rubber, respectively. The price of the premium quality product was Rp 8,800/kg, 9% higher than those of the poor- and better-quality products, respectively. The higher price indicates that rubber factories are responsive to premium quality. Even though the weight loss during drying was 15% higher for the premium-quality slab rubber than the poor- and better-quality slab rubber, no weight reduction was imposed on the premium product. In that case, an accurate checking system was unnecessary. In summary, the premium quality received a higher gross margin than those of the poor- and better-quality slab rubber products. Farmer Z was able to produce a premium product because of the size of his plot, the experience and skill of his employees, and because he was able to monitor processing. Consequently, he produced rubber according to the RMS.

At present, the farmer organization organizes the selling of slab rubber and provides credit to farmers, but it does not monitor slab rubber processing. Consequently, there are wide variations in the quality of slab rubber, and most of it is poor quality. Peer monitoring, where all of the farmers participate in monitoring quality, would be one strategy to increase the quality of slab rubber in farmer organizations.

The findings of this study provide important baseline data for related research, and will be useful for policy makers in terms of the development of rubber farming in Indonesia. As discussed in this thesis, rubber farming in Indonesia began in 1876 on private plantations, and after independence in 1945, 75% of the rubber plantations were government-owned. In Indonesia, rubber trees are cultivated in rainforest areas, which were abundant in the past but are becoming scarcer as the population increases. A recent estimate is that smallholder rubber farmers contribute 80% of total rubber production in Indonesia.

When rubber was first cultivated in Indonesia, the smallholder rubber farmers cultivated rubber trees with other perennial crops such as timber and rattan. At that time, smallholder farmers planted local (unselected) rubber varieties in the “jungle rubber” system. The productivity was low, but it was sufficient at that time. These conditions were referred to as the "development of agricultural preconditions" by Johnston and Mellor (1961). In this phase, farmers expanded their land tenure by opening remote forests. Thus, rubber farming was responsive to international demands, referred to as "vent for surplus" by Myint (1958), Hayami (2001). However, as the population increased, the landholdings became smaller, and so farmers began to plant HYV (selected seedlings and bud grafts) to increase productivity. Some farmers cultivated HYV with other perennial crops, a system known by some as the "rubber agroforestry system", and by others as the "monoculture system". This phase was described as the "expansion of agricultural production based on labor-intensive, capital-saving techniques, relying heavily on technological innovations" by Johnston and Mellor (1961) or as the "high-pay off input model" by Schultz (1964) in Hayami and Ruttan (1985). Most of the rubber exported from Indonesia is low quality. The low productivity and low quality decrease the competitiveness of Indonesia's rubber sector. This research discussed these issues in detail.

This research clearly shows that applying improved technology can increase the productivity and income of rubber farmers. The land productivity using improved technology is 29%–38% higher than that using un-improved technology. Consequently, the farmer income is also 29%–38% higher using improved technology. The use of improved technology is an example of a high pay-off input model, as mentioned by Hayami and Ruttan (1985). In that model, (1) the agricultural experiment station has the capacity to produce a high yield variety, (2) the industry has the capacity to develop, produce, and market new technological inputs, and (3) the farmer has the capacity to use modern agricultural methods effectively. Johnston and Kilby (1975) and Johnson and Ruttan (1994) suggested that within a small farm structure, advanced technologies can be used if they are divisible. In this case, one farmer grew a HYV, applied fertilizer, and used stimulant, but did not use machinery to clear land. Agricultural research to produce new HYVs is an important component of economic development (Johnston and Mellor, 1960).

There were low adoption rates of improved technology in the research area, because of the cost of replanting, the high cost of maintenance, and income loss during the gestation period. One farmer that adopted improved technology was able to sell rubber logs. This was profitable because his plot was near a road, and so the transport costs were low. Therefore, to increase the rate of adopting new technology, the government could provide better roading infrastructure for smallholder farmers, and/or provide credit to farmers for replanting.

The low quality of slab rubber is due to asymmetric information among farmers, traders, and rubber factories. This asymmetry arises from the inaccurate quality checking system. To address this problem, a peer monitoring system could be introduced in farmer organizations, to improve the quality of their product.

By adopting improved technology, the productivity of smallholder farmers will increase, and their incomes will increase accordingly. The introduction of peer monitoring and guidance services to farmer organizations would improve rubber quality at both the farm and factory levels. Finally, from a macroeconomic point of view, the increased productivity and quality of the rubber product, and the resulting increase in farmer income would mean that the rubber sector would make a greater contribution to the Indonesian economy.

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